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DESIGN CRITERIA FOR ELASTOMERIC BEARINGS

Volume III - Program User's Manual

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A Division of Thiokol Corporation
Brigham City, Utah 84302

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Final Report

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Prepared for

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EUSTIS DIRECTORATE POSITION STATEMENT

The data contained in this report are the results of an effort designed to improve the state of the art of elastomeric bearing design for helicopter rotor head applications. The products of this effort are a design manual and a computer program based on finite-element techniques. The results of this program are contained in the following four volumes:

Volume I - Final Report
Volume II - Design Manual
Volume III - Program User's Manual
Volume IV - Programmer's Manual

Volume I contains the development and background information used in producing the design manual.

Volume II presents design considerations and procedures, bearing applications, methods of analysis, and techniques for predicting bearing performance.

Volumes III and IV contain the computer code and examples of problems showing sample inputs and outputs.

The products of this effort provide a good foundation for building a comprehensive manual and computer code for the design and analysis of elastomeric bearings for helicopter rotor head applications. It was recognized at the onset of this program that both the manual and the code would be first editions. The results of this effort were expected to define areas requiring further development. Further investigations coupled with feedback from users and/or evaluators are expected to provide material for upgrading the content and format of the manual and codes.

Mr. John Sobczak of the Military Operations Technology Division served as project engineer for this effort.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document describes the usage and input of a program that performs a stress analysis on an axisymmetric body with isotropic materials. The body may have asymmetric loads, in which case several passes through the program are required to obtain the complete solution. The accumulation routine will accumulate all the harmonics of the Fourier expansion. The program is a compressible formulation; that is, Poisson's ratio must be less

20.
than .5, but it may be as close to it as desired.

An extensive input module has been included in the program to make it as user oriented as possible. This includes routines that will automatically generate bearing geometry based on basic input parameters.

The basic program is written in FORTRAN IV with some support routines written in IBM 370 Assembler Language.

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METHOD

The theoretical basis of the program is contained in Volume I and is not repeated in this manual.

Variable dimensions of the grid have been used throughout so that any size problem can be run if sufficient computer size and time are available.

The solution scheme is a Gaussian reduction. This gives good answers with reasonably short run times.

The program may be run as a standard axisymmetric program giving either one or both of the axisymmetric or torsion solutions. Multiple passes may be made through the program inputting the proper load coefficients to gain an asymmetric loading solution. The accumulation routine will accumulate the displacements and strains for all harmonics to give the final solution.

The program is a finite-element program. To solve for the displacements, stresses and strains throughout a body, it is divided into many small pieces called elements by defining a grid network of nodes over a cross section of the body. For each element, a stiffness matrix is defined according to the basic assumptions for that element. A force vector is created by applying the pressures and loads to the nodes. The element stiffness matrices and force vectors are then assembled into a master set of equations, and the equations are solved using a Gaussian reduction technique. This method of solution has been extensively used at Thiokol for many years and has yielded good answers in reasonably short run times.

There are two basic elements available in this program, and one or the other must be selected in the RUN input section. The first is the linear displacement element. The assumption for it is that the displacements are a linear function through the element. This element is used for the basic axisymmetric runs, the asymmetric loading runs and the torsion runs.

The second element is the isoparametric element. It is a quadratic element where the displacements are assumed to be a quadratic function through the element. This element will in general give better results for the same size or a smaller grid. It has not, however, been as extensively used as the linear element.

In the Type of Material section, there are five element types given. Types 1, 2, 4 and 5 are all linear elements and differ only in the number of degrees of freedom they can handle.

LOAD DEFINITIONS

For the single-pass, axisymmetric run, loads are input directly as they apply to the entire body of revolution.

For asymmetric loading, a Fourier expansion of the form

$$f(\theta) = A_0 + \sum_{n=1}^{N} A_n \cos n\theta + \sum_{n=1}^{N} B_n \sin n\theta$$

must be generated, where N is the number of terms needed to accurately represent the load. All loads are defined in terms of this function of theta. The loads are then input with the constant term A_n in the first pass and either A_n or B_n being entered for the n+1st pass.

The assumption is implicit in the program that the loads are symmetric about the 0^o - 180^o plane through the body. Because of this symmetry, the radial and axial loads can go in only as an even function and the tangential loads only as an odd function. That is, only the A terms can be used for R or Z loads, and only the B terms can be used for the θ loads.

The units of the function f and the coefficients A and B must be in pounds per square inch for pressure, or pounds for nodal point load, over the entire surface affected.

Pressure, shear and traction loads act on the entire surface of revolution on which they are applied. That is, the total load is equal to πDLP where D is the diameter, L the length, and P the pressure or shear.

Nodal point forces apply a load directly to a point and are not distributed over any surface. They are a load on a ring as the loaded point is revolved about the axis.

See Appendix B for the description of a program to generate the Fourier coefficients.

PROGRAM COORDINATES

The normal orientation of the coordinate system is with the R-axis horizontal and the Z-axis vertical. This is referred to here as a right-handed system; that is, R rotated into Z gives a vector out of the paper.

The indexing system of the program can also be layed out as a coordinate system. By definition, a right-handed system is one in which the I axis rotated into the J axis gives a vector out of the paper.

The two systems, coordinate and indexing, must always agree. That is, they must both be either right-handed or left-handed. If one is right and the other left, the program will give negative area errors on the grid and stop execution.

All angles in the system are measured from the positive R axis counterclockwise in the right-handed system. If the system is transformed, this relative orientation must be maintained.

There are "local origins" referred to in the input section. These are simply temporary origins to aid in the designating of that one node or line. The point will be translated back into the global coordinate system by adding the coordinates of the local origin to the coordinates of the point.

THE LINE GENERATOR

By means of the Line Generator Record, line and arc segments may be generated internally to connect any* two points with a set of nodes. The following options are available:

A. Equal interval - In the straight line all intervals between nodes are equal. In an arc the angular intervals are equal.

B. Square root of r - Where N is the total number of intervals and I goes from 1 to N-1, each interval is $(2I-1)/N^2$ of the total length. For a line, this is an increment of length; for an arc, it is an angular interval.

C. Geometric progression - The increments of length or angle will be in a geometric progression. Any of r (the common ratio), a (the first interval), or l (the last interval) may be specified. In addition, the second node in the line may be specified and r will be calculated using the interval from the first node to the second node of the line as a.

Any of these options may be used to generate any line in the figure. The lines may go in either ascending or descending order of I or J.

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*Either I or J must be constant for all the nodes in a line or arc.

THE GRID GENERATOR

The grid generator used in this program is one developed at Thiokol by Dr. William Cook.* This is a linear interpolation method which yields a good grid under most conditions regardless of the curvature of the boundaries.

A two-dimensional space is defined in ζ and η, and the grid boundary nodes are mapped into this space. A linear interpolation scheme is then used to fill in the remainder of the ζ, η space. Two functions, f and g, are then defined that map the ζ, η space into the X,Y space of the grid. These functions are then used to define the remainder of the grid.

There may be any number of major partitions in the grid and any number of subpartitions within each of these.

A major partition is defined as a closed rectangular section of matrix (the figure may be of any shape, but the section of matrix must be capable of being defined by a minimum and maximum of I and J), all of which will be generated by one and only one grid generation record. The subpartitions are closed rectangular sections of matrix lying within the major partition.

All boundaries of each partition must be completely specified, and there must be no nodes specified that do not lie on the boundaries of a partition.

Each major partition must be specified on a Grid Generator Record, but the program will pick up all subpartitions lying within the specified major partition.

Due to the nature of the Cook grid generator, the following restrictions must be observed when using it:

1. All sections of the matrix that are to be generated by it must be rectangular and the boundaries must be completely defined.

2. If interior nodes are specified, they must form rectangular subsections of the section of matrix being generated. There is no limit to the number of such subsections allowed.

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*Cook, William A., BODY ORIENTED (NATURAL) CO-ORDINATES FOR GENERATING THREE-DIMENSIONAL MESHES, International Journal for Numerical Methods in Engineering, Vol 8, 1974, pp. 27-43.

INPUTTING THE PROGRAM

There are several things about the program that you should be aware of as you set up your input. The sections below define both general things to keep in mind and the specific methods of input required for the various options. For additional information, see Vol II of this report.

I General

The RUN section must always be used to specify both the geometry type and the element type. In this version of the program, the geometry type is always axisymmetric (option 3). The element type can be either linear displacement (option 4) or isoparametric (option 5).

Each node defines an element, except for isoparameteric, where it is every other node. The elements are referenced by the node with the smallest indices of the nodes comprising the element. Those nodes which lie on the boundary of the geometry and do not reference a real element are given a type code of 9, which signifies a missing element. This type code of 9 is also used to code an internal element which has no material in it. Type 9 elements require no material code, and this can be set to 0 or left blank.

Plots can be produced quite simply by specifying the orientation desired, the range of indices of the nodes to be plotted, and the Y paper size. The data will then be scaled to fit the paper height, and the same scale factor will be used for the X direction. The actual scale values used, the minimum values and the maximum values, if calculated, will be printed when each plot is produced.

Several input sections use index increments referred to as II and JI. The value II is an I index increment, that is, we go from I1 to I2 in increments of II. The value JI is a J index increment, and we go from J1 to J2 in increments of JI. For example, if we have a grid where we have material 1 in the elements with an even J index and material 2 in the elements with an odd J index, we can apply these in only 2 records by using a JI of 2. Another example of its use is in the isoparametric input. This is explained more fully in section VII below.

II **The Basic Axisymmetric Problem**

This is the case for which there are no iterations and the basic linear displacement element is being used. The RUN section must show this by inputting options 3 and 4.

III **Asymmetric Loading**

The asymmetric loading of an axisymmetric body is accomplished by making multiple passes through the program within one run. Each pass has the harmonic coefficients for one term in the Fourier expansion entered as load conditions. Run option 9, asymmetric loading, must be specified in each pass.

The node number, L11 in the General Data, and the highest harmonic allowed, L12 in the General Data, must both be specified in each pass, and the highest harmonic allowed must be nonzero.

The accumulation of the output is necessary for proper interpretation of the results. Each pass will give results that are the maximum for each coordinate direction. These values have meaning only when multiplied by the proper sine and cosine terms and added to the other terms for that node or element.

The undeformed geometry can be plotted at any time in the run. Accumulation and plotting of the deformed geometry must be in the last pass only. Plots can be made of the displaced geometry at any angle θ or axial location Z by accumulating the data where desired and then inputting a plot section immediately after. The plot routines will always plot the last data accumulated. See the sample input for an example of this.

IV **Incremental Loading**

When this option is used, the program automatically cycles through as many times as there are load increments. The cumulative totals of the displacements and strains may be printed out for each increment under the control of the Selective print option. The print suppress option (output option 1) and the Selective print section control the output of the final results, and the incremental loading print flag with the Selective print option controls all others.

All loads and boundary conditions may be applied in increments. The fraction of the load to be applied in each step may be specified, or on a flag the increments will be calculated in an arithmetic progression.

A set of flags is provided so that specified loads may not be applied incrementally.

Each iteration is handled essentially as a separate run with the program looping through the entire solution scheme. The displaced geometry reflecting all the previous loading is used in each iteration so that stiffness due to bending will be taken into consideration.

V <u>Large Deformation</u>

The use of this option takes into consideration the nonlinear terms in the strain displacement relationship and iterates for the final solution. You can also enter strain dependent material properties to take into consideration the nonlinear material behavior.

A Convergence criteria and a series of underrelaxation factors must be entered. The underrelaxation factors must be positive values no greater than 1.0, and at least the last two values must be 1.0. The program will iterate until convergence or the maximum number of iterations is satisfied.

As in the incremental loading option, the print suppress flag controls the final output and the large deformation print flag controls all others.

The energy calculation, reaction forces and accuracy check are not valid for this option and are not allowed.

VI <u>Incremental Loading and Large Deformation</u>

These two options may be combined to allow a large deformation iteration inside each incremental loading loop. The controls on each remain the same, and the same set of underrelaxation factors will be used for each increment of load.

VII Isoparametric Elements

The isoparametric element in this program is a quadratic element with three nodes on each side. The geometry is input and generated just as if a linear displacement element were being used. Note, however, that all element boundaries and material boundaries must fall on nodes with odd indices.

The internal handling of this element requires some special consideration in the input. The element type codes and material numbers must only be on the nodes which designate element corners. To achieve this, II and JI in the TYPE section must be input as 2's.

VIII Torsion

The torsion solution is part of the zero harmonic in the asymmetric loading case, because it is the only element at present that has a theta degree of freedom. A RUN parameter of 9 must then be specified.

There are to different ways that torsion can be run: (1) with the full asymmetric calculation giving all three degrees of freedom, and using a type 4 element: (2) with torsion only, in which case a type 5 element will be used. The type 5 element is faster than the type 4. Accumulation can be made for both elements, or for any combination of 2, 4 or 5 elements, since they are all asymmetric. Note that the torsion loads act on a moment arm equal to the radial coordinate of the point where they are applied.

IX Stability

This option is used to determine the stability of a flat, vertically stacked bearing. The only input sections required are the General Input, the Run input, and the Stability input. The values in the General section will not be used, but due to program flow the section must be included. Run option 20 must be specified.

X Service Life

To determine the service life of a bearing, this program must be used in conjunction with program S3359SL. When a run is made where data needs to be saved for the service life calculations, output option 20 must be specified. The stresses and

strains will then be output on a file whose name is SERVLIFE. Each set of data put on this file will be identified by two integers which are printed on the output: the first is the julian date and the second is the time of day in centiseconds. These will be used to identify the set of data for program S3359SL. These sets can be put on separate reels of tape, or they can be stacked together on one tape by using the proper Job Control Language.

TIMING

Timing on this program is a problem because so many factors affect the execution speed.

In general the time required for a run is a function of I^2 and J.

The asymmetric loading problem requires about two times as long for each pass as a simple axisymmetric problem.

Each iteration on iterative runs must be counted as a full execution.

From our experience, the best way to estimate the time is by experience with the guidelines given above. However, the following equation will give a starting point:

$$\text{Time (in minutes)} = F\, I^2\, J + 1.2$$

where F = .0012 for an asymmetric run and .0006 for an axisymmetric run, I is the I-dimension of the grid, and J is the J-dimension of the grid. This equation is for the IBM 370/155; the factor F and the constant 1.2 may change for other machines.

RESTRICTIONS

1. The isotropic Poisson's ratio is restricted to $0 < \nu < .5$. At least under some circumstances a zero Poisson's ratio will make the stiffness matrix singular.

2. If a node is on the axis of revolution of an axisymmetrically loaded body, the radial displacement of that node must be fixed at zero.

3. At least one axial component of displacement must be specified to avoid rigid-body axial motion. A sliding boundary condition may also fulfill this requirement if it restrains axial motion.

4. In any row of the grid, I must run consecutively through each value $IMIN \leq I \leq IMAX$ for that row. Type 9 elements may be used where needed to provide "voids" in the grid.

5. In the input, a maximum of 9 digits is allowed on each side of the decimal point in a number.

6. There is a maximum of 32,767 materials allowed in the program. However, due to the special internal handling, the number of materials used with isoparametric elements is limited to 50.

VARIABLE DIMENSIONS

To facilitate running of both large and small problems, the working arrays in the program have been variably dimensioned. Two things should be noted here about the program. First, the program will take as much core storage as it is given; that is, on the step resource usage given at the end of the run, the amount of core used and requested will always be the same. Second, the actual amount of working storage used in each phase will be printed out as part of the output.

The table on the following pages gives the maximum core required for a run. There are many factors which affect the core required for any given run, so the first guess should be taken from the table and then adjusted after a complete run has been made. The excess core available for each part of the program is given with the output.

To find the region required for a run, a look in the table for the I and J size of the grid will give the region in K bytes. If an asymmetric loading case, or an isoparametric case is not being run, the region may be reduced by up to one-third.

For a stability calculation, only 190K will be needed for the run.

MAX STORAGE REQUIRED FOR S3359

J	I=6	I=8	I=10	I=12	I=14	I=16	I=18	I=20	I=22	I=24	I=26	I=28	I=30	I=32	I=34	I=36	I=38	I=40	I=42	I=44	I=46	I=48	I=50	I=52	I=54
5	196	205	215	226	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
10	196	205	215	226	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
15	196	205	215	226	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
20	196	205	215	226	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
25	198	205	215	226	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
30	201	205	215	226	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
35	204	206	215	226	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
40	207	209	215	226	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
45	210	212	215	226	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
50	213	216	218	226	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
55	217	219	222	226	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
60	220	223	225	228	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
65	223	226	229	232	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
70	226	229	233	236	239	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
75	229	233	236	240	243	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
80	233	236	240	243	247	254	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
85	236	239	243	247	251	255	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
90	239	243	247	251	255	259	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
95	242	246	250	255	259	263	270	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
100	245	250	254	258	263	267	272	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
105	248	253	258	262	267	271	276	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
110	252	256	261	266	271	276	280	288	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
115	255	260	265	270	275	280	285	290	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
120	258	263	268	274	279	284	289	294	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
125	261	267	272	277	283	288	293	299	307	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
130	264	270	275	281	287	292	298	303	309	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
135	268	273	279	285	291	296	302	308	314	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
140	271	277	283	289	295	301	307	313	319	327	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
145	274	280	286	292	299	305	311	317	323	330	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
150	277	283	290	296	303	309	315	322	328	335	350	373	399	425	454	484	515	548	583	619	656	695	736	778	822
155	280	287	293	300	307	313	320	326	333	340	352	373	399	425	454	484	515	548	583	619	656	695	736	778	822
160	283	290	297	304	311	317	324	331	338	345	357	373	399	425	454	484	515	548	583	619	656	695	736	778	822
165	287	294	301	308	315	322	328	335	342	350	362	375	399	425	454	484	515	548	583	619	656	695	736	778	822
170	290	297	304	311	319	326	333	340	347	355	368	380	399	425	454	484	515	548	583	619	656	695	736	778	822
175	293	300	308	315	322	330	337	345	352	360	373	386	399	425	454	484	515	548	583	619	656	695	736	778	822
180	296	304	311	319	326	334	342	349	357	365	378	392	405	425	454	484	515	548	583	619	656	695	736	778	822
185	299	307	315	323	330	338	346	354	362	370	384	398	411	425	454	484	515	548	583	619	656	695	736	778	822
190	302	310	318	326	334	342	350	358	366	375	389	403	417	431	454	484	515	548	583	619	656	695	736	778	822
195	306	314	322	330	338	347	355	363	371	380	395	409	423	438	454	484	515	548	583	619	656	695	736	778	822
200	309	317	326	334	342	351	359	368	376	385	400	415	429	444	459	484	515	548	583	619	656	695	736	778	822
205	312	321	329	338	346	355	364	372	381	390	405	420	436	451	466	484	515	548	583	619	656	695	736	778	822
210	315	324	333	342	350	359	368	377	385	395	411	426	442	457	473	488	515	548	583	619	656	695	736	778	822
215	318	327	336	345	354	363	372	381	390	400	416	432	448	464	479	495	515	548	583	619	656	695	736	778	822
220	322	331	340	349	358	367	377	386	395	405	421	438	454	470	486	502	519	548	583	619	656	695	736	778	822
225	325	334	344	353	362	372	381	390	400	410	427	443	460	476	493	510	526	548	583	619	656	695	736	778	822
230	328	338	347	357	366	376	385	395	405	415	432	449	466	483	500	517	534	551	583	619	656	695	736	778	822
235	331	341	351	360	370	380	390	400	409	420	437	455	472	489	507	524	541	559	583	619	656	695	736	778	822
240	334	344	354	364	374	384	394	404	414	425	443	460	478	496	513	531	549	566	584	619	656	695	736	778	822
245	337	348	358	368	378	388	399	409	419	430	448	466	484	502	520	538	556	574	592	619	656	695	736	778	822
250	341	351	361	372	382	393	403	413	424	435	453	472	490	509	527	545	564	582	601	619	656	695	736	778	822
255	344	354	365	376	386	397	407	418	429	440	459	478	496	515	534	553	571	590	609	628	656	695	736	778	822
260	347	358	369	379	390	401	412	422	433	445	464	483	502	522	541	560	579	598	617	636	656	695	736	778	822
265	350	361	372	383	394	405	416	427	438	450	470	489	508	528	547	567	586	606	625	645	664	695	736	778	822
270	353	365	376	387	398	409	420	432	443	455	475	495	515	534	554	574	594	614	634	653	673	695	736	778	822
275	357	368	379	391	402	413	425	436	448	460	480	500	521	541	561	581	601	622	642	662	682	702	736	778	822
280	360	371	383	394	406	418	429	441	452	465	486	506	527	547	568	588	609	629	650	671	691	712	736	778	822

MAX STORAGE REQUIRED FOR S3359

J	I=6	I=8	I=10	I=12	I=14	I=16	I=18	I=20	I=22	I=24	I=26	I=28	I=30	I=32	I=34	I=36	I=38	I=40	I=42	I=44	I=46	I=48	I=50	I=52	I=54
285	363	375	386	398	410	422	434	445	457	470	491	512	533	554	575	596	616	637	658	679	700	721	742	778	822
290	366	378	390	402	414	426	438	450	462	475	496	518	539	560	581	603	624	645	666	688	709	730	752	773	822
295	369	381	394	406	418	430	442	455	467	480	502	523	545	567	588	610	631	653	675	696	718	740	761	783	822
300	372	385	397	410	422	434	447	459	472	485	507	529	551	573	595	617	639	661	683	705	727	749	771	793	822
305	376	388	401	413	426	439	451	464	476	490	512	535	557	579	602	624	647	669	691	714	736	758	781	803	825
310	379	392	404	417	430	443	456	468	481	495	518	541	563	586	609	631	654	677	699	722	745	768	790	813	836
315	382	395	408	421	434	447	460	473	486	500	523	546	569	592	615	638	662	685	708	731	754	777	800	823	846
320	385	398	412	425	438	451	464	477	491	505	529	552	575	599	622	646	669	692	716	739	763	786	810	833	856
325	388	402	415	429	442	455	469	482	495	510	534	558	581	605	629	653	677	700	724	748	772	796	819	843	867
330	392	405	419	432	446	459	473	487	500	515	539	563	588	612	636	660	684	708	732	757	781	805	829	853	877
335	395	408	422	436	450	464	477	491	505	520	545	569	594	618	643	667	692	716	741	765	790	814	839	863	888
340	398	412	426	440	454	468	482	496	510	525	550	575	600	625	649	674	699	724	749	774	799	823	848	873	898
345	401	415	429	444	458	472	486	500	515	530	555	581	606	631	656	681	707	732	757	782	808	833	858	883	908
350	404	419	433	447	462	476	491	505	519	535	561	586	612	637	663	689	714	740	765	791	817	842	868	893	919
355	407	422	437	451	466	480	495	510	524	540	566	592	618	644	670	696	722	748	774	800	825	851	877	903	929
360	411	425	440	455	470	485	499	514	529	545	571	598	624	650	677	703	729	756	782	808	834	861	887	913	940
365	414	429	444	459	474	489	504	519	534	550	577	603	630	657	683	710	737	763	790	817	843	870	897	923	950
370	417	432	447	463	478	493	508	523	533	555	582	609	636	663	690	717	744	771	798	825	852	879	906	933	960
375	420	436	451	466	482	497	512	528	543	560	587	615	642	670	697	724	752	779	807	834	861	889	916	943	971
380	423	439	454	470	486	501	517	532	548	565	593	621	648	676	704	732	759	787	815	843	870	898	926	954	981
385	427	442	458	474	490	505	521	537	553	570	598	626	654	683	711	739	767	795	823	851	879	907	935	964	992
390	430	446	462	478	494	510	526	542	558	575	604	632	660	689	717	746	774	803	831	860	888	917	945	974	
395	433	449	465	481	498	514	530	546	562	580	609	638	667	695	724	753	782	811	840	868	897	926	955	984	
400	436	452	469	485	502	518	534	551	567	585	614	643	673	702	731	760	789	819	848	877	906	935	964	994	
405	439	456	472	489	506	522	539	555	572	590	620	649	679	708	738	767	797	826	856	886	915	945	974		
410	442	459	476	493	510	526	543	560	577	595	625	655	685	715	745	775	804	834	864	894	924	954	984		
415	446	463	480	497	514	531	547	564	581	600	630	661	691	721	751	782	812	842	872	903	933	963	994		
420	449	466	483	500	518	535	552	569	586	605	636	666	697	728	758	789	819	850	881	911	942	973			
425	452	469	487	504	521	539	556	574	591	610	641	672	703	734	765	796	827	858	889	920	951	982			
430	455	473	490	508	525	543	561	578	596	615	646	678	709	740	772	803	835	866	897	929	960	991			
435	458	476	494	512	529	547	565	583	601	620	652	684	715	747	779	810	842	874	905	937	969				
440	461	479	497	515	533	551	569	587	605	625	657	689	721	753	785	817	850	882	914	946	978				
445	465	483	501	519	537	556	574	592	610	630	663	695	727	760	792	825	857	889	922	954	987				
450	468	486	505	523	541	560	578	597	615	635	668	701	733	766	799	832	865	897	930	963	996				
455	471	490	508	527	545	564	583	601	620	640	673	706	740	773	806	839	872	905	938	972					
460	474	493	512	531	549	568	587	606	624	645	679	712	746	779	813	846	880	913	947	980					
465	477	496	515	534	553	572	591	610	629	650	684	718	752	786	819	853	887	921	955	989					
470	481	500	519	538	557	576	596	615	634	655	689	724	758	792	826	860	895	929	963	997					
475	484	503	523	542	561	581	600	619	639	660	695	729	764	798	833	868	902	937	971						
480	487	507	526	546	565	585	604	624	644	665	700	735	770	805	840	875	910	945	980						
485	490	510	530	549	569	589	609	629	648	670	705	741	776	811	847	882	917	953	988						
490	493	513	533	553	573	593	613	633	653	675	711	746	782	818	853	889	925	960	996						
495	496	517	537	557	577	597	618	638	658	680	716	752	788	824	860	896	932	968							
500	500	520	540	561	581	602	622	642	663	685	721	758	794	831	867	903	940	976							
505	503	523	544	565	585	606	626	647	668	690	727	764	800	837	874	911	947	984							
510	506	527	548	568	589	610	631	651	672	695	732	769	806	844	881	918	955	992							
515	509	530	551	572	593	614	635	656	677	700	738	775	812	850	887	925	962	1000							
520	512	534	555	576	597	618	639	661	682	705	743	781	819	856	894	932	970								
525	516	537	558	580	601	622	644	665	687	710	748	786	825	863	901	939	977								
530	519	540	562	583	605	627	648	670	691	715	754	792	831	869	908	946	985								
535	522	544	565	587	609	631	653	674	696	720	759	798	837	876	915	954	992								
540	525	547	569	591	613	635	657	679	701	725	764	804	843	882	921	961	1000								
545	528	550	573	595	617	639	661	684	706	730	770	809	849	889	928	968									
550	531	554	576	599	621	643	666	688	711	735	775	815	855	895	935	975									
555	535	557	580	602	625	648	670	693	715	740	780	821	861	901	942	982									
560	538	561	583	606	629	652	675	697	720	745	736	827	867	908	949	989									

FREFRM INPUT

Input to the program is via subroutine FREFRM. This is a record-oriented free-form input routine. It allows data to be entered without regard to card columns and yet be input as individual unique records.

This routine has the following characteristics:

1. Numbers are not restricted to any particular columns on the card.

2. The numbers may be separated with any of the following:

   a. A comma is a separator.

   b. The sign of the number is a separator.

   c. The single quotation mark (') when defining an alpha string is also a separator.

   d. The end of a card (column 72) is a separator; that is, if no other separator is encountered before the end of a card, that end will terminate the number. Note that an end of card in an alpha string is an error.

   e. The L of an L-number is a separator.

   f. A record terminator (;) will terminate the number as well as the record. A record terminator in an alpha string is an error. A string of dissimilar separators is only one separator. For example, a comma followed by an end of card, followed by an L or quote, is still only one separator.

3. L-Numbers may be used to specify the relative location of the value <u>in the record</u>. An L-Number is an integer preceded by an L which sets the counter to a specific location in the record, the first location being 1. Thus the third location is given by L3. The L-Number must be separated from the following value by a valid separator. The number must always follow the L immediately. The presence of anything other than a digit immediately following the L will

cause an error.

4. A logical record must be terminated by a semicolon (;).

5. Alphanumeric data can be entered anywhere in the string but must be set off with single quotation marks ('). The quotation mark is a separator. Two consecutive quotation marks will cause a quotation mark to be entered in the string. There are 8 characters in each location as defined by the L-Numbers.

6. If two commas appear consecutively, no value is input between them. The value previously put in that location will remain there.

7. If two signs appear consecutively, a zero is assumed between them.

8. If a record begins with an alpha character, it will be assumed to be a flag record or a title, and no other data may be entered in it. These records may begin with 'L', which usually signifies an L-Number, if and only if the second character in the string is alphabetic.

9. Comments may be punched in any card by punching an asterisk (*) followed by any desired comments. The asterisk and all data following it in that card will be ignored.

10. Only the first 72 columns of each card will be used, so columns 73-80 may be used for sequence numbers if desired.

11. Data entered in a location in a record stays in that location in subsequent records until it is changed by entering a new value in that location.

12. A maximum of 9 digits is allowed on each side of the decimal point in a number.

FLAG AND TITLE RECORDS

Any record which begins with alphabetic data is considered to be a flag or title record. Flag records are used to flag the beginning of each group of records. If the first four columns of the record contain a flag sequence, the record is considered to be a flag record. If not, it is considered to be a title record and its use is determined from its location in the input stream. The record terminator must not appear in the string. A title record may span several cards, but each flag or title record must end with a record terminator. A flag record cannot exceed a single card.

In the following pages, only four characters are given for each flag since this is all that is checked. Additional characters may be added to make a full statement if desired.

INPUT FOR PROGRAM

As many of the following groups as needed may be entered. Some of the groups are required; others are optional.

The Title records and General Data must be the first two groups input. All other groups may be input in any order, with the only restriction being that of logical sequence of events. Obviously you can not use an item of data until it is input; therefore, Line Generators must follow the Node records that define their end points, etc. In general, any group may be input more than once; however, this practice should be restricted to avoid overly complex input sets.

Each case run through the program is considered to be a separate case, and all information must be entered for each case. This is also true of the various parts of an asymmetric loading run. Except for the accumulation, each case is considered to be completely separate.

Note that only columns 1 through 72 may be used for data.

Title

As many cards as desired may be entered here, with the last card containing a record terminator. Each title card must start with an alphabetic character.

General Data - The flag is GENE

L1	Minimum I value
L2	Minimum J value
L3	Maximum I value
L4	Maximum J value
L5-L9	Not used at present
L10	Base temperature
L11	Mode number if asymmetric loading
L12	Highest mode allowed if asymmetric loading

Run Parameters - The Flag is RUN

Run options will be selected from the following table by entering the option numbers as a sequence of integers. The blank options represent options not available in this version of the program.

1.

2.

3. Axisymmetric geometry

4. Linear displacement element

5. Isoparameteric element

6.

7.

8.

9. Asymmetric loading of an axisymmetric geometry

10. Mesh only - check input and test the grid. Geometry plots will be produced if requested.

11.

12.

13.

14.

15.

16.

17.

18.

19.

20. Stability calculation

Output Options - The Flag is OUTP

The options are selected by entering the option numbers from the following table. These options apply to the entire output set; if output is desired for specified sets of nodes or elements only, then use the Selective Print option.

If no output options are specified, the output will be the displacements for each node and the stresses and strains for each element.

1. Print Suppress. The displacements and stresses will not print except as specified by the Selective Print option.

2. Punch the deformed grid.

3. Print the deformed grid.

4.

5.

6.

7.

8. Accuracy check. Calculate (F-KU) for each element and print the 10 elements with the highest error.

9. Reaction forces. Print the reaction forces for the nodes with displacement boundary conditions.

10.

11.

12.

13.

14. Print the strain energy.

15. Print the element material properties.

16. Print the loads for each element with nonzero loads and the boundary conditions for each node with nonzero boundary conditions.

17.

18.

19.

20. Output data on tape for service life calculation.

Special Points - The Flag is SPEC

This section allows for a maximum of 100 special points that are not part of the grid. Their purpose is to provide convenient points to be used as local origins for nodes, arcs, etc.

L1	K The special point number. It will be referenced by this number whenever it is used.
L2	X or R coordinate
L3	Y,θ or Z coordinate
L4	If nonzero the values in L2 and L3 are considered to be R and θ, in degrees. If zero, they are considered to be X and Y.
L5	The number of a previously input special point may be input here, and it will be used as a local origin for point K.

Nodes - The flag is NODE

Each of these records defines one geometry point in the grid.

L1	I
L2	J
L3	R(I,J)
L4	Z(I,J) or θ in degrees
L5	Spherical flag - input a +1 if R and θ are input instead of R and Z.

L6	Local origin flag	

L6 Local origin flag

0 - no local origin

1 - special point whose number is in L7 is the local origin

2 - the node whose indices are given in L7 and L8 will be used as the local origin

3 - the coordinates of the local origin are given in L7 and L8

L7 K, IL or RL depending on L6

L8 JL or ZL depending on L6

Line Generators - The flag is LINE

Each record generates a sequence of node points between the existing end points. Either I1 = I2 or J1 = J2 must hold.

L1	I1	Beginning node of the line.
L2	J1	
L3	I2	Ending node of the line.
L4	J2	

L5 Rotation code

+1 if rotating from the positive R to the positive Z axis.

-1 if rotating from the positive Z to the positive R axis.

L6 Nodal spacing option code

'0' equal interval option

'1' the square root of r option

'2' geometric progression with 'r' specified

	'3' geometric progression with 'a' specified
	'4' geometric progression with 'l' specified
	'5' geometric progression with the second node in the line defined previously and used to define 'a'
L7	This field will contain a, r or l depending on which option was specified in L6.
L8	GMIN -The smallest interval allowed for a geometric progression.
L9	GMAX - The largest interval allowed for a geometric progression.
L10	If the sequence of nodes is to form an arc, the way in which the arc center is given is specified here.
	0 - not arc - generate a straight line
	1 - the special point whose number is given in L11 is the arc center
	2 - the node whose indices are given in L11 and L12 is the arc center.
	3 - the center of the arc is at the coordinates given in L11 and L12
L11	K, IC or RC depending on L10
L12	JC or ZC depending on L10

<u>Bearing Generator</u> - The flag is BEAR

This section contains parameters necessary to generate a spherical or conical bearing model only.

The node points will be generated and element type and material codes will be set as specified for the elements generated. Type of Material records do not need to be input for the elements of the bearing.

See Figure 1 for the relative location of the indices.

L1	The minimum I value in the bearing. This may be any value. Default of 1. IMNB
L2	The maximum I value in the bearing IMXB
L3	The minimum J value in the bearing. Default of 1. JMNB
L4-6	Not used at present.
L7	IEQU If this is nonzero the nodes will be equally spaced across the bearing in the I direction instead of having the first and last interval half the others.
L8	Element type - see Type of Material section for valid types.
L9	+0 if a spherical bearing.
	+1 if a conical bearing.
L10	The inside radius of the bearing for spherical bearings only.
L11	Radial coordinate for node IMNB, JMNB.
L12	Radial coordinate for node IMNB, JMXB*.
L13	Radial coordinate for node IMXB, JMNB.
L14	Radial coordinate for node IMXB, JMXB*.
L15-18	Contain the axial coordinates of the corner nodes. For a spherical bearing their only function is to place the node in the proper quadrant; they need not be accurate since they will be recalculated to be sure that the node lies on the proper circle. For a conical bearing they will be used as input.
L15	Axial coordinate for node IMNB, JMNB.

*JMXB is JMAX for the bearing and is internally calculated.

L16	Axial coordinate for node IMNB, JMXB*.
L17	Axial coordinate for node IMXB, JMNB.
L18	Axial coordinate for node IMXB, JMXB*.

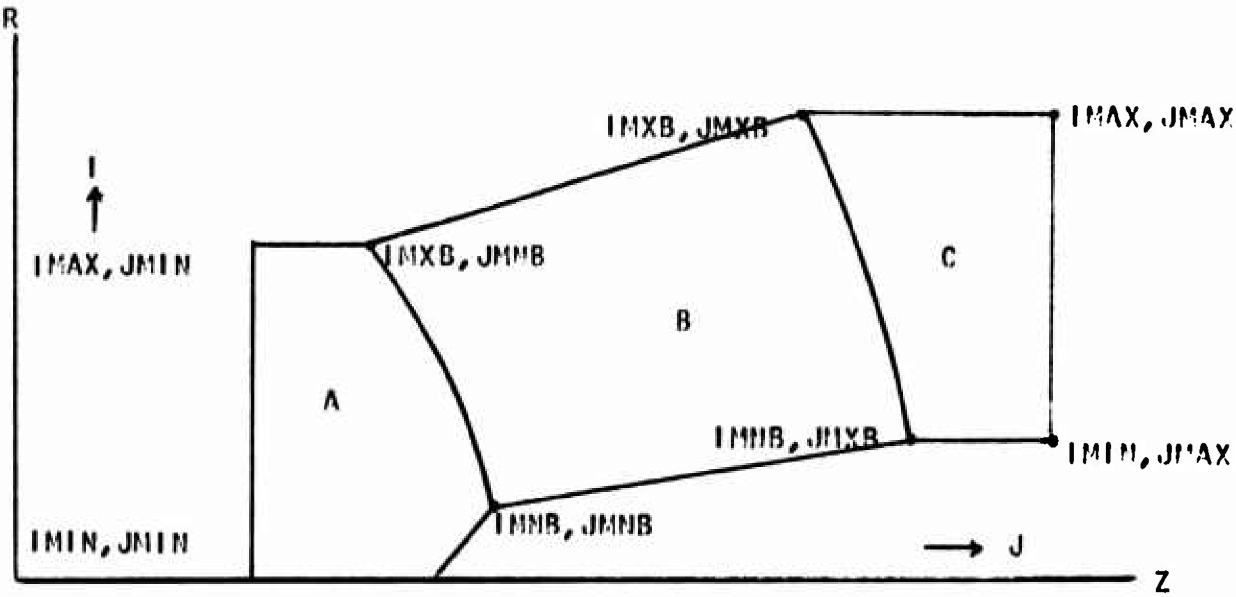

Figure 1. Bearing Example

The complete geometry goes from IMIN,JMIN to IMAX,JMAX. Parts A and C are attachment appliances on the ends of the bearing B. The bearing is defined between indices IMNB, JMNB and IMXB, JMXB.

L19	TS thickness of the shim.
L20	NS number of columns in one shim.
L21	ISN number of shims.
L22	TE thickness of the elastomer.
L23	NE number of columns in one elastomer.
L24	IEN number of elastomers.
L25-29	Not used at present.

*JMXB is JMAX for the bearing and is internally calculated.

L30	MS material number for shim. Default of 1
L31	ME material number for elastomer. Default of 2
L32-49	Not used at present.
L50-99	**SHIMT shim thickness for each of the shims if not constant. Any value left blank or zero will be replaced by the constant value in L19.
L100-149	**ELAST elastomer thickness for each elastomer if not constant. Any value left blank or zero will be replaced by the constant value in L22.
L150-199	**MATS material number for the shims if not constant. Any value left blank or zero will be replaced by the constant value in L30.
L200-249	**MATE material number for the elastomers if not constant. Any value left blank or zero will be replaced by the constant value in L31.

<u>Grid Generator</u> - The flag is GRID

L1	I1	These specify the region to be generated. The generator used is the Cook grid generator, and the region specified must be a closed rectangular system in the I, J plane.
L2	J1	
L3	I2	
L4	J2	

**Starting with JMNB and proceeding in order out to JMXB

Type of Material - The flag is TYPE

Each of these records assigns a material number and an element type to a block of elements. A material property table must be input for each number assigned here. Note that these are element indices.

L1 I1

L2 J1

L3 I2

L4 J2

L5 Element type

The valid element types are:

1 Axisymmetric with R and Z degrees of freedom

2 Axisymmetric with R, θ and Z degrees of freedom. Used for asymmetric loading.

3 Isoparametric quadratic element with three nodes per side and R and Z degrees of freedom.

4 Element to be used on mode 0 of an asymmetric loading run when theta loads are used. Torsion in connection with radial and axial loads.

5 Element to be used on mode 0 of an asymmetric loading run when torsion is the only load. This element is much faster then type 4.

9 Null or void element. This type must be assigned to the last node in each row and column. It may also be used to define holes in the material. It is automatically assigned to the nodes on IMAX and JMAX.

L6 Material number

L7 II - if input, I will go from I1 to I2 in increments of II

L8 JI - if input, J will go from J1 to J2 in increments of JI

__Boundary Conditions__ - The flag is BOUN

Each record assigns boundary conditions to a set of nodes.

L1	I1
L2	J1
L3	I2
L4	J2
L5	R boundary condition code*
L6	R boundary condition value or harmonic coefficient
L7	θ boundary condition code*
L8	θ boundary condition value or harmonic coefficient
L9	Z boundary condition code*
L10	Z boundary condition value or harmonic coefficient
L11-12	not used at present
L13	Sliding boundary condition code, 0 or 1 only.
L14	Angle in degrees of the line the node must slide on. See Figure 2.
L15	II if input, I will go from I1 to I2 in increments of II
L16	JI if input, J will go from J1 to J2 in increments of JI

*The valid codes are:

0 - no boundary condition

1 - displacement boundary condition

2 - A nodal force is to be applied. Nodal forces are the forces on the entire circumference.

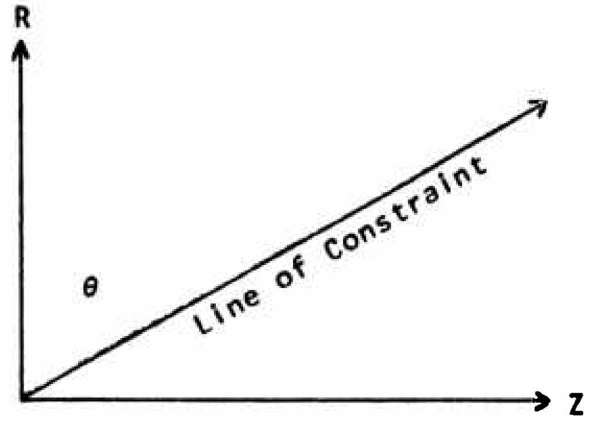

Figure 2. Sliding Boundary Condition

Pressures - The flag is PRES

Each record puts pressure along a line of nodes. P is normal to the element surface and S is parallel to it. The values PR, PTH and PZ are traction loads in the coordinate system and will decompose into pressure and shear components internally.

L1	I1
L2	J1
L3	I2
L4	J2
L5	Direction code:

0 if the pressure is to be applied to the elements to the left of the line moving from point I1, J1 to point I2, J2.

1 if the pressure is to be applied to the elements on the right.

See Figures 3 and 4.

Note: This code is correct for a right-handed indexing system. For a left-handed indexing system, the codes must be interchanged. That is, 0 is pressure to the right and 1 to the left.

L6	P1	Pressure at node I1, J1
L7	P2	Pressure at node I2, J2
L8	S1	Shear at node I1, J1
L9	S2	Shear at node I2, J2
L10	PR1	Radial traction at node I1, J1
L11	PR2	Radial traction at node I2, J2
L12	PTH1	Theta traction at node I1, J1
L13	PTH2	Theta traction at node I2, J2
L14	PZ1	Axial traction at node I1, J1
L15	PZ2	Axial traction at node I2, J2

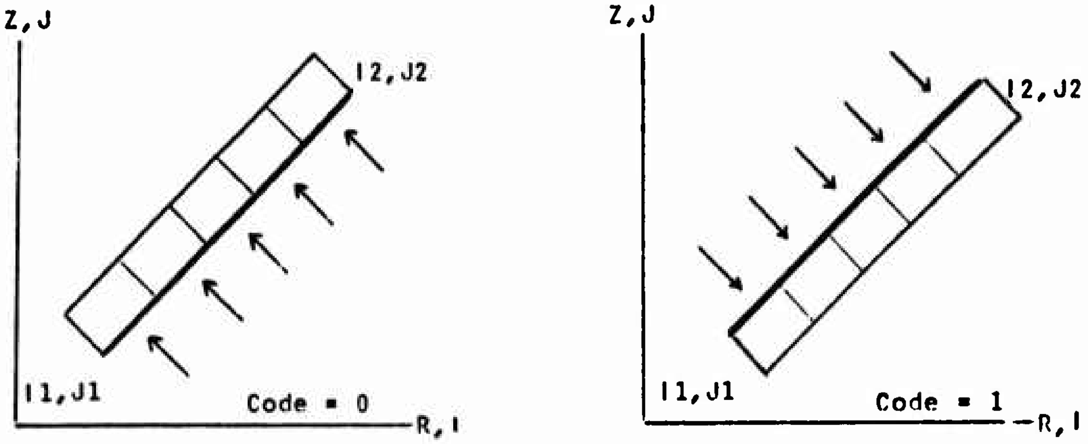

Figure 3. Right-handed Pressure Convention

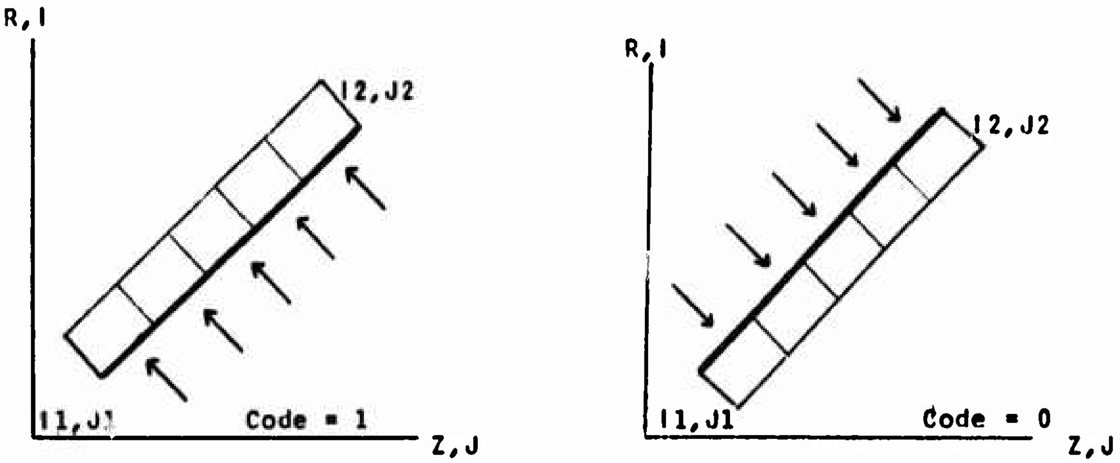

Figure 4. Left-handed Pressure Convention

__Body Force Loads__ - The Flag is BODY

L1	I1
L2	J1
L3	I2
L4	J2
L5	Radial body force harmonic coefficient ($\rho\omega^2$)
L6	Theta body force harmonic coefficient (F)
L7	Axial body force harmonic coefficient (F/L^3)

__Temperature Distribution__ - The Flag is TEMP

There are two ways in which a temperature distribution may be applied in this program. Only one form may be used in any one run.

A. Constant temperature over the whole body.

The first record must be the word CONSTANT enclosed in single quotation marks. This record must be followed by one record of the following form:

L1 The constant temperature

B. Radius vs temperature tables

The first record must be the character string R vs T enclosed in single quotation marks. This record will be followed by as many records of the following form as necessary to completely define the temperature of each element:

L1	I1	These are node point
L2	J1	indices which define
L3	I2	the area over which

L4	J2	this table applies.
L5	R1	
L6	T1	Temperature at radius R1
L7	R2	
L8	T2	Temperature at radius R2

Material Properties - The flag is MATE

This program accepts isotropic materials only.

For nonstrain or temperature-dependent materials, only one record is entered for each material.

For materials that are strain or temperature dependent, several records will be entered for each material. One record must be entered for each entry in the table. The material number and name need not be entered on each record of the table. If the table is strain dependent, the strain value in the first record must be nonzero and the table must be so input that a zero strain value can be found. If the table is temperature dependent, the temperature value in the first record must be nonzero.

L1	Material number
L2	Young's modulus (E) or large deformation K1*
L3	Poisson's ratio (ν) or large deformation K2*
L4	Alpha for thermal loading
L5	Temperature for which these material properties apply if they are temperature dependent.
L6	Strain at which these material properties apply if they are strain dependent (large deformation).
L7-9	A 24-character material name enclosed in quotation marks.

*See Vol II for definition.

NOTE: Due to special internal handling of material properties, do not use L-Numbers in the input. Always specify missing parameters by commas.

Selective Print Option - The Flag is SELE

This section may be used to ask for output of displacements, stresses and material properties if the overall output of those items has been suppressed in the Output section. As many records as desired may be entered.

L1	I1
L2	J1
L3	I2
L4	J2

Incremental Loading - The Flag is INCR

This section will cause the program to iterate, applying a portion of the load each time and accumulating the results.

L1 The number of increments (N) over which the loads will be applied. If this is positive, then the second record for this set must be entered with N fractions on it. If negative, the loads will be applied in an arithmetic progression.

L2 If a nonzero value is input, printout of material properties, displacements and stress/strains will be made each iteration for those nodes specified by the selective print. The complete output will be printed on the final increment unless the print suppress flag, output option 1, is turned on.

The following set of flags tells which loads will be applied incrementally. If the flag is zero, the load will be applied in increments; if nonzero the full load, if any, will be applied in each iteration.

L3 Pressure and traction loads PR, PTH and PZ

L4 Shear

L5 Temperature

L6 R body force

L7 Z body force

L8 R nodal load

L9 Z nodal load

L10 Nodal displacements

Incremental loading fraction record

This record must be entered if N is positive and may be entered to override calculated values if N is negative.

L1 Fraction for 1st increment

L2 Fraction for 2nd increment

etc.

for N (max. of 100) increments

<u>Large Deformation</u> - The Flag is LARG

This section controls the large deformation iteration. One record of the following form must be entered.

L1 The number of the last iteration to be allowed.

L2 If nonzero, printout of displacements will be made each iteration for those nodes specified by the Selective print option.

L3 Convergence factor. Convergence is attained when the absolute value of the largest change in displacements is less than this value.

L4-103 The underrelaxation factors for iterations 1-99. The default value is 1.0.

Geometry Plots - The Flag is GEOM

This section is used to request the plotting of the geometry, either deformed or undeformed. Plots for which the displacement multiplier is zero will be produced during the input phase at the time the plot section is encountered. It is possible to plot the geometry at any point in its development by putting geometry plot sections in at the desired points, such as after the node records, etc.

Note that data will not carry over from one record to the next in this section.

L1	Axis parameter option 1 if the R-axis is to be horizontal to the right 2 if the Z-axis is to be horizontal to the right	
L2	I1	These indices define the region of the geometry to be plotted.
L3	J1	
L4	I2	
L5	J2	
L6	The displacement multiplier. If zero, the original geometry will be plotted. If nonzero, the displacements will be multiplied by this before being added to the node coordinates for plotting.	
L7	X-axis scale factor*	

*The X and Y axes here refer to the paper rather than the geometry. Not all of these parameters need be entered. The maximum and minimum values will be obtained from the data if not specified. Also, both the scale factors and the paper size need not be specified. The relation Scale = paper size /(Max - Min) will be used to find any missing data. The scale factor will always be used if entered. If the scale factors are not input, they will be calculated to keep the plot on the paper. If the X paper size and scale factor are not entered, the Y scale factor will be used for both axes.

L8	Y-axis scale factor*
L9	Minimum value on the X-axis*
L10	Maximum value on the X-axis*
L11	Minimum value on the Y-axis*
L12	Maximum value on the Y-axis*
L13	X-axis paper size*
L14	Y-axis paper size*
L15	The X location in inches of the beginning of the title.
L16	The Y location in inches of the beginning of the title.
L17	The letter size for the title in inches.
L18-19	Not used at present
L20-25	Up to 48 characters of plot title information as an alpha string enclosed in quotation marks.

<u>Accumulation Control</u> - The Flag is ACCU

This section must be entered only on the last case of an asymmetric loading run. Under control of these records the displacements and strains will be read in for each mode and accumulated. The accumulated output will be printed. It may also be plotted by putting a geometry plot request after the desired displacements have been calculated; thus there may be several Accumulation and Plot sections alternating in the input.

*The X and Y axes here refer to the paper rather than the geometry. Not all of these parameters need be entered. The maximum and minimum values will be obtained from the data if not specified. Also, both the scale factors and the paper size need not be specified. The relation Scale = paper size /(Max - Min) will be used to find any missing data. The scale factor will always be used if entered. If the scale factors are not input, they will be calculated to keep the plot on the paper. If the X paper size and scale factor are not entered, the Y scale factor will be used for both axes.

Note that to plot a transverse cut, I goes from 1 to the maximum number of nodes in the Radial direction and J goes from 1 to 19.

L1 Option Flag

1 Output will be an axial cut at angle θ.

2 Output will be a transverse cut at the axial distance Z.

L2 θ or Z depending on L1.

Stability - The flag is STAB

This section is used to input the data for the stability calculation. Run option 20 must be specified for the calculations to be made. The stack is assumed to be a vertical stack beginning and ending with a rubber pad; hence the number of shims is assumed to be one less than the number of rubber pads.

L1 The thickness of each rubber pad.

L2 The thickness of each shim.

L3 The inside diameter of the stack if it is cylindrical.

L4 The outside diameter.

L5 The number of rubber pads.

L6 The Young's modulus for the rubber pads.

L7 The convergence accuracy factor. When (1 - old buckling load/new buckling load) is less than this value, the iteration has converged.

L8 The maximum number of iterations to be allowed.

End of Harmonic - The flag is END

An end record must terminate the input for each portion of the run. This signals the program to stop reading and solve the problem as defined.

SAMPLE INPUT

Two cases are shown here. They are illustrations only and do not necessarily reflect real problems.

Sample case 1 is a flat bearing. It is set up in a right-handed system. Figure 5 is a plot of the geometry, and arrows have been drawn in to show the R, Z, I and J axes. This is purely a bearing with no additional parts added. The output for this case is not given in this document since its form is similar to that of case 2.

Sample case 2 is a spherical bearing with a steel attachment on one end. It is oriented in a left-handed system. Figure 6 is a plot of the geometry, and arrows have been drawn in to show the axes. Note how the input sections are ordered to achieve the desired results. The output from this case is given here to show its form.

SAMPLE PROBLEM 1

```
                                       SAMPLE PROBLEM 1  ;
GENERAL DATA ;
  1, 1, 6, 14 ;
RUN ;
  3, 4 ;
OUTPUT ;
  8, 9, 14 ;
BEARING ;
  1, 6, 1, 18, 1, 1,, C, C, 3.C, 3.0, 0, 2.0, 0, 2.C,
    .55, 2, 2, .3, 3, 3 ;
BCUNDARY COND ;
  1, 1, 1, 14, 1, 0 ;
  1, 1, 6, 1, 0, 0, 0, C, 1, 0 ;
BOCY FORCE ;
  1, 1, 6, 4, 0, C, 1C. ;
  1, 6, 6, 9 ;
  1, 11, 6, 14 ;
  1, 4, 6, 6, 0, 0, 3C. ;
  1, 9, 6, 11 ;
MATERIALS ;
  1, 1.0E6, .3,,,, ' STEEL SHIM' ;
  2, 300., .49999,,,, 'RUBBER PAC' ;
GEOMETRY PLCT ;
  1, 1, 1, 6, 14, 0, 3., 3., -.333,, -.333,,,, 1.C, 8.5, .12,
    L20 'SAMPLE 1' ;
  1, 1, 1, 6, 14, 5.0, 4., 4., C,, C,,,, 1.0, 8.5, .12,
   L20, 'DEFORMED SAMPLE 1' ;
ENC ;
```

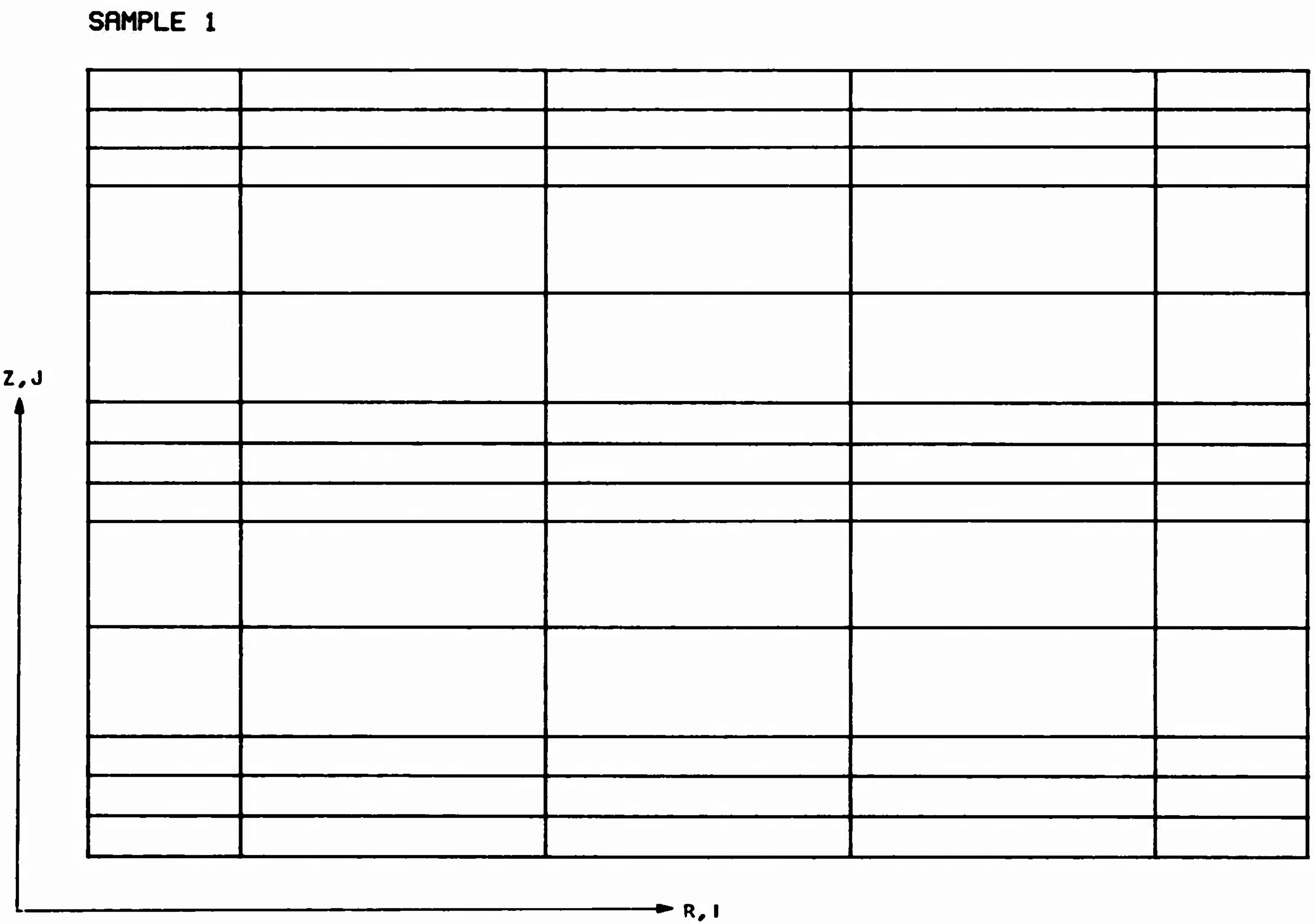

Figure 5. Sample Problem 1

SAMPLE PROBLEM 2

```
          SAMPLE PROBLEM 2,    ZERCTH HARMCNIC ;
GENERAL CATA ;
 1, 1, 6, 16, L11, 0, 1 ;
RUN ;
 3, 4, 9;
NCCES ;
 1, 1, 0.0, 9.0 ;
 6, 1, 3.0, 9.0 ;
BEARING ;
 1, 6, 3, L8, 2, C, 1C.C, C, C, 2.0, 3.C, 1C.C, 12.C, 9.0, 11.0,
    .3, 2, 2, .24, 3, 3;
LINES ;
 1, 1, 6, 1 ;
 1, 1, 1, 3 ;
 6, 1, 6, 3 ;
GRID ;
 1, 1, 6, 3 ;
TYPE ;
 1, 1, 5, 2, 2, 1 ;
BCLNDARIES ;
 1, 2, 1, 16, 1, 0 ;
 1, 1, 6, 1, 1, 0, 1,C, 1, 0 ;
PRESSURE ;
 1, 16, 6, 16, 1, 50., 50. ;
MATERIALS ;
 1, 1.0E6, .3,,,, ' STEEL ' ;
 2, 300., .49999,,,, 'RLBBER' ;
GECMETRY PLCT ;
 2, 1, 1, 6, 16, C, 2.0, 2.C, 8.C,, -1.C,,,, 2.C, 3.3, .12 ,
    L2C, ' SAMPLE 2  LNCEFCRMEC';
ENC OF HARMCNIC ;
        SAMPLE PRCBLEM 2,      FIRST HARMCNIC ;
GENERAL DATA ;
 1, 1, 6, 16, L11, 1, 1 ;
RUN ;
 3, 4, 9;
NCCES ;
 1, 1, 0.0, 9.C ;
 6, 1, 3.0, 9.C ;
BEARING ;
 1, 6, 3, L8, 2, O, 1C.C, C, C, 3.C, 3.C, 10.C, 12.C, 9.0, 11.0,
    .3, 2, 2, .24, 3, 3;
LINES ;
 1, 1, 6, 1 ;
 1, 1, 1, 3 ;
 6, 1, 6, 3 ;
```

```
GRID ;
 1, 1, 6, 3 ;
TYPE ;
 1, 1, 5, 2, 2, 1 ;
BOUNDARIES ;
 1, 1, 6, 1, 1, 0, 1,0, 1, 0 ;
PRESSURE ;
 6, 1, 6, 16, 0, 100., 100.;
MATERIALS ;
 1, 1.0E6, .3,,,, ' STEEL ' ;
 2, 300., .49995,,,, 'RUBBER' ;
ACCUMULATION ;
 1, 0 ;
GEOMETRY PLOT ;
 2, 1, 1, 6, 16, 5, 2.0, 2.0, 8.0,, -1.0,,,, 2.0, 8.3, .12 ,
     L20, ' SAMPLE 2  DEFORMED 5X';
END OF HARMONIC ;
```

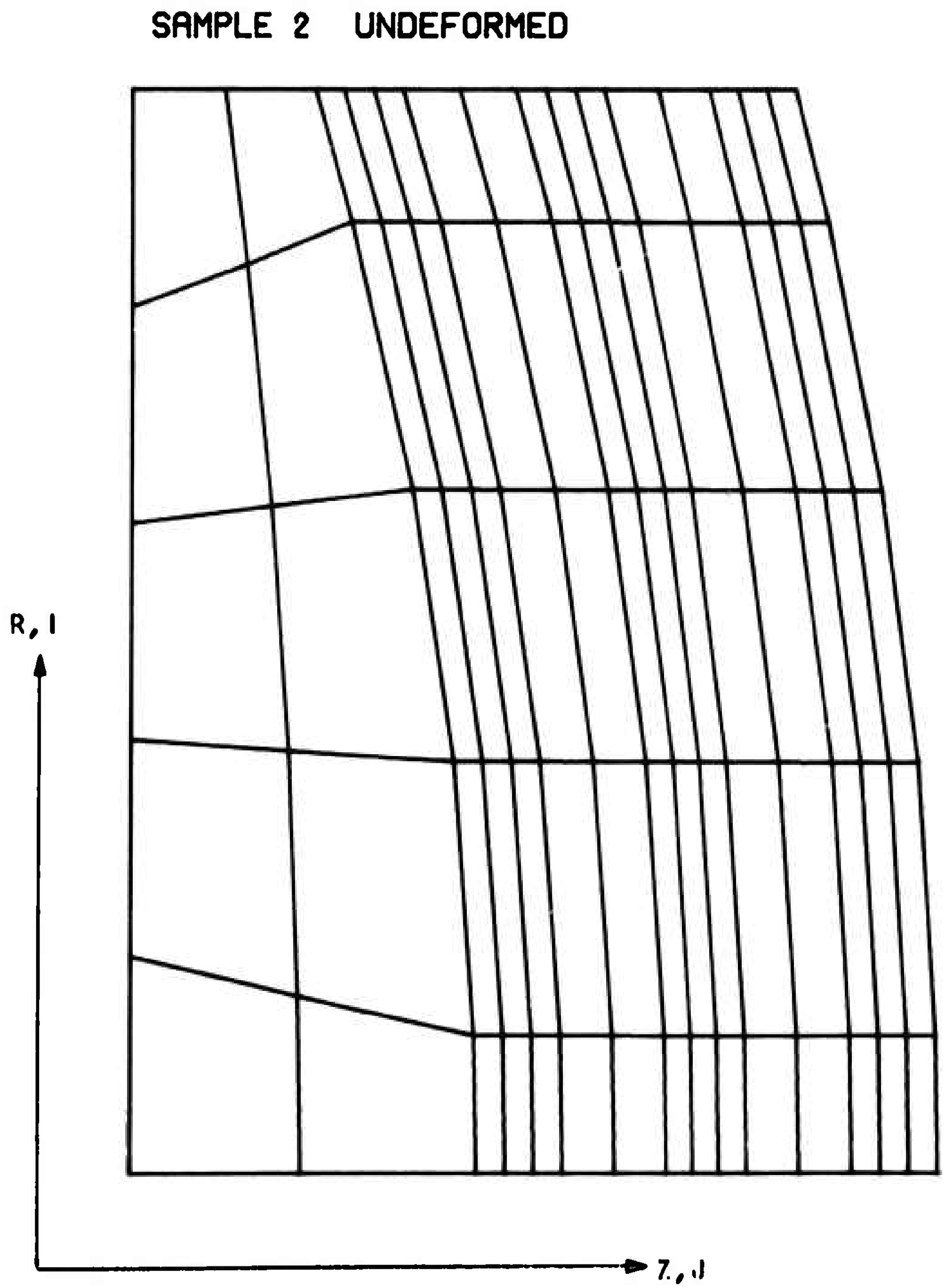

Figure 6. Sample Problem 2

SAMPLE OUTPUT

The output shown is for Sample Input Case 2. Some of the pages are combined to save space, and in some cases the full output is not shown. Note that the input for the second pass has been heavily abbreviated since most of it is the same as for the first pass.

Figure 7 is a plot of the deformed geometry with the displacements multiplied by 5.

SAMPLE 2 DEFORMED 5X

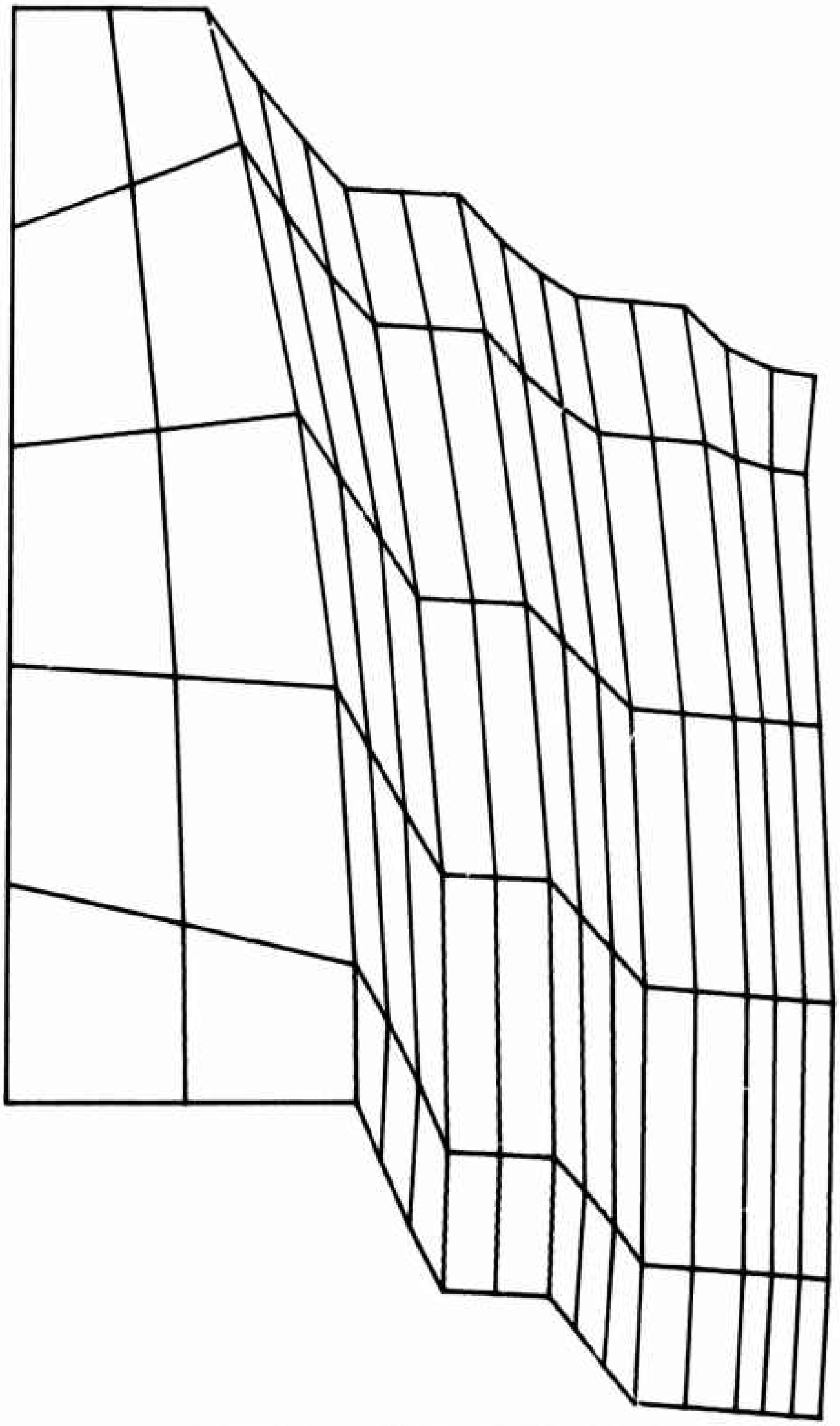

Figure 7. Deformed Sample 2

```
                         THIOKOL AUTOMATED STRESS SYSTEM

            SAMPLE PROBLEM 2,   ZEROTH HARMONIC


PROG S3359          SAMPLE PROBLEM 2,   ZEROTH HARMONIC                      DATE  8/20/75 TIME C8:49  PAGE     1
                                          *** GENERAL DATA ***

                                  THE GENERAL INPUT VALUES INPUT ARE:
    1.00000000000          1.00000000000          6.00000000000          16.00000000000
   0.0                    0.0                    0.0                    0.0
   0.0                    0.0                    0.0                     1.00000000000

     THE GENERAL DATA VALUES ARE:
          IMIN                     1
          JMIN                     1
          IMAX                     6
          JMAX                     16
   BASE TEMPERATURE =       0.0    MODE =    0  MAX MODE =    1

                                       *** RUN PARAMETERS DATA ***

     THE RUN FLAGS ARE:
          3.,    4.,    9.,

   THE RUN PARAMETER OPTIONS THAT ARE IN EFFECT FOR THIS CASE ARE:

        AXISYMMETRIC
        LINEAR DISPLACEMENT ELEMENT
        ASYMMETRIC LOADING


PROG S3359          SAMPLE PROBLEM 2,   ZEROTH HARMONIC                      DATE  8/20/75 TIME C8:49  PAGE     2
                NODE INPUT RECORDS
      I    J          R               Z OR THETA    POL   IL OR K   JL      RL            ZL

      1    1      0.0               9.0000000 00    0
      6    1      3.0000000 00      9.0000000 00    0
```

```
PROG S3359          SAMPLE PROBLEM 2,   ZEROTH HARMONIC                              DATE  8/20/75 TIME 08:49  PAGE      3
                  BEARING GENERAL PARAMETERS

          IMIN =   1                   IMAX =   6                JMIN =   3                 JMAX =  10
          IVEC =   0                   VANG =   0.0

             ELEMENT TYPE FOR BEARING ELEMENTS IS    2

             A SPHERICAL BEARING WILL BE GENERATED.

                  GEOMETRY

           RI =    1.000000 01         RF =    1.132000 01
          RII =    0.0                 RIF =   0.0            RFI =    3.000000 00        RFF =   3.000000 00
          ZII =    [illegible].000000 01         ZIF =   1.200000 01    ZFI =    9.000000 00        ZFF =   1.100000 01
           TS =    3.000000-01         NS =    2              ISN =    2
           TE =    2.400000-01         NE =    3              IEN =    3

                  MATERIAL PROPERTIES

           MS =   1                    ME =   2


PROG S3359          SAMPLE PROBLEM 2,   ZEROTH HARMONIC                              DATE  8/20/75 TIME 08:49  PAGE      4
                                           LINE GENERATOR RECORDS
   I1   J1   I2   J2  RCD  OPT       XIN         GMIN            GMAX          IC   JC      RC            ZC

    1    1    6    1   0.    0       0.0          0.0             0.0
    1    1    1    3   0.    0       0.0          0.0             0.0
    6    1    6    3   0.    0       0.0          0.0             0.0


PROG S3359          SAMPLE PROBLEM 2,   ZEROTH HARMONIC                              DATE  8/20/75 TIME 08:49  PAGE      5
               GRID GENERATOR RECORDS
                I1         J1         I2         J2

                1          1          6          3
  PARTITION GENERATED FROM    1    1 TO    6    3


PROG S3359          SAMPLE PROBLEM 2,   ZEROTH HARMONIC                              DATE  8/20/75 TIME 08:49  PAGE      6
            MATERIAL TYPE RECORDS
               I1      J1      I2      J2     TYPE     MAT    I-INC   J-INC

               1       1       5       2       2        1       1       1
```

```
PROG S3359          SAMPLE PROBLEM 2.   ZEROTH HARMONIC                          DATE  8/20/75 TIME 08:49  PAGE      7

                                          BOUNDARY CONDITION RECORDS
                             X OR R           THETA            Y OR Z             ROTATION           SLIDING
     I1    J1    I2    J2  CODE    VALUE    CODE    VALUE     CODE    VALUE      CODE    VALUE      CODE    VALUE      II    JJ

      1     2     1    16     1  0.0           0  0.0            0  0.0            0  0.0            0  0.0           1     1
      1     1     6     1     1  0.0           1  0.0            1  0.0            0  0.0            0  0.0           1     1


PROG S3359          SAMPLE PROBLEM 2.   ZEROTH HARMONIC                          DATE  8/20/75 TIME 08:49  PAGE      8

                                                      PRESSURE RECORDS

    I1    J1    I2    J2   ICD      P1        P2        S1        S2       PR1       PR2      PTH1      PTH2       PZ1       PZ2

     1    16     6    16     1    50.00     50.00      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0


PROG S3359          SAMPLE PROBLEM 2.   ZEROTH HARMONIC                          DATE  8/20/75 TIME 08:49  PAGE      9
                                               ISOTROPIC MATERIAL PROPERTIES

      MAT      NAME                        E             NU          ALPHA          TEMP           STRAIN

       1     STEEL                   1.000000 06   3.00000D-01   0.0           0.0            0.0

       2    RUBBER                   3.00000D 02   4.99990D-01   0.0           0.0            0.0


PROG S3359          SAMPLE PROBLEM 2.   ZEROTH HARMONIC                          DATE  8/20/75 TIME 08:49  PAGE     10
                                                     GEOMETRY PLOTS
IFLG  MIN   MAX     DISPM      SCALE       MIN       MAX       SIZE     TITLE   TITL          PLOT TITLE
      I/J   I/J                 X/Y        X/Y       X/Y        X/Y      X/Y    SIZE

  2     1     6     0.0        2.000      8.000     0.000      0.000     2.000    0.12   SAMPLE 2  UNDEFORMED
        1    16                2.000     -1.000     0.000      0.000     8.300

   PLOT FOR      1     1     6    16   WITH X & Y SCALE FACTORS    2.0000000 00    2.0000000 00
        THE X & Y MINS & MAXS ARE    8.0000000 00  -1.0000000 00    1.9037950-77    1.9037950-77
```

GRID COORDINATES AND PARAMETERS

I	J	R	Z	TYPE	MAT	PRNT FLG	RADIAL		AXIAL		BOUNDARY CONDITIONS ROTATION		THETA		SLIDING	
1	1	0.000000	9.000000	2	1	0	1	0.0	1	0.0	0	0.0	1	0.0	0	0.0
2	1	0.600000	9.000000	2	1	0	1	0.0	1	0.0	0	0.0	1	0.0	0	0.0
3	1	1.200000	9.000000	2	1	0	1	0.0	1	0.0	0	0.0	1	0.0	0	0.0
4	1	1.800000	9.000000	2	1	0	1	0.0	1	0.0	0	0.0	1	0.0	0	0.0
5	1	2.400000	9.000000	2	1	0	1	0.0	1	0.0	0	0.0	1	0.0	0	0.0
6	1	3.000000	9.000000	9	0	0	1	0.0	1	0.0	0	0.0	1	0.0	0	0.0
1	2	0.000000	9.500000	2	1	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	2	0.491090	9.492028	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	2	1.170125	9.464509	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	2	1.846351	9.412501	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	2	2.517511	9.336290	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	2	3.000000	9.265696	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	3	0.000000	10.000000	2	2	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	3	0.380774	9.992748	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	3	1.140113	9.934795	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	3	1.892840	9.819224	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	3	2.634589	9.646706	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	3	3.000000	9.535392	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	4	0.000000	10.080000	2	2	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	4	0.380679	10.072809	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	4	1.139864	10.015344	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	4	1.892546	9.900741	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	4	2.634432	9.729654	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	4	3.000000	9.623222	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	5	0.000000	10.160000	2	2	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	5	0.380586	10.152069	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	5	1.139621	10.095883	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	5	1.892260	9.982232	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	5	2.634278	9.812552	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	5	3.000000	9.706987	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	6	0.000000	10.240000	2	1	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	6	0.380455	10.232928	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	6	1.135384	10.176414	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	6	1.891981	10.063698	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	6	2.634128	9.895401	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	6	3.000000	9.790689	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	7	0.000000	10.390000	2	1	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	7	0.380331	10.383037	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	7	1.138956	10.327385	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	7	1.891475	10.216380	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	7	2.633857	10.050617	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	7	3.000000	9.947467	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	8	0.000000	10.540000	2	2	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	8	0.380175	10.533141	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	8	1.138546	10.478326	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	8	1.890553	10.368980	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	8	2.633598	10.205673	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	8	3.000000	10.104039	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	9	0.000000	10.620000	2	2	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	9	0.380094	10.613196	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	9	1.138335	10.558816	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	9	1.890744	10.450334	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	9	2.633464	10.288307	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

GRID COORDINATES AND PARAMETERS

I	J	R	Z	TYPE	MAT	PRNT FLG	RADIAL		AXIAL		BOUNDARY CONDITIONS ROTATION		THETA		SLIDING	
6	9	3.000000	10.187463	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	10	0.000000	10.700000	2	2	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	10	0.380016	10.693250	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	10	1.138129	10.639298	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	10	1.890501	10.531667	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	10	2.633334	10.370899	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	10	3.000000	10.270832	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	11	0.000000	10.780000	2	1	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	11	0.379939	10.773302	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	11	1.137928	10.719772	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	11	1.890263	10.612978	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	11	2.633267	10.453450	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	11	3.000000	10.354149	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	12	0.000000	10.930000	2	1	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	12	0.379799	10.923399	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	12	1.137563	10.870642	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	12	1.889833	10.765381	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	12	2.632975	10.608126	2	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	12	3.000000	10.510228	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	13	0.000000	11.080000	2	2	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	13	0.379666	11.073493	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	13	1.137214	11.021486	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	13	1.889421	10.917714	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	13	2.632754	10.762667	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	13	3.000000	10.666133	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	14	0.000000	11.160000	2	2	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	14	0.379597	11.153542	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	14	1.137033	11.101926	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	14	1.889208	10.998931	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	14	2.632640	10.845036	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	14	3.000000	10.749214	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	15	0.000000	11.240000	2	2	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	15	0.379529	11.233591	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	15	1.136857	11.182359	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	15	1.889000	11.080130	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	15	2.632528	10.927369	2	2	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	15	3.000000	10.832248	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1	16	0.000000	11.320000	9	0	0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	16	0.379463	11.313638	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
3	16	1.136685	11.262786	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
4	16	1.888797	11.161310	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5	16	2.632419	11.009667	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
6	16	3.000000	10.915237	9	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

DISPLACEMENTS FOR ASYMMETRIC LOADING MODE = 0

I	J	R-COORDINATE	Z-COORDINATE	R-DISPLACEMENT	THETA-DISPLACEMENT	Z-DISPLACEMENT
1	1	0.00000	9.00000	0.0	0.0	0.0
2	1	0.60000	9.00000	0.0	0.0	0.0
3	1	1.20000	9.00000	0.0	0.0	0.0
4	1	1.80000	9.00000	0.0	0.0	0.0
5	1	2.40000	9.00000	0.0	0.0	0.0
6	1	3.00000	9.00000	0.0	0.0	0.0
1	2	0.00000	9.50000	0.0	0.0	-2.88912D-05
2	2	0.49109	9.49203	2.79403D-07	0.0	-2.85118D-05
3	2	1.17013	9.46451	2.19437D-06	0.0	-2.55486D-05
4	2	1.84635	9.41250	5.27647D-06	0.0	-1.84665D-05
5	2	2.51791	9.33629	8.11402D-06	0.0	-8.92067D-06
6	2	3.00000	9.26970	9.73493D-06	0.0	-6.98414D-06
1	3	0.00000	10.00000	0.0	0.0	-5.61854D-05
2	3	0.38077	9.99275	-1.81824D-06	0.0	-5.61919D-05
3	3	1.14011	9.93479	-3.20846D-06	0.0	-5.26120D-05
4	3	1.89284	9.81922	2.30206D-07	0.0	-3.70323D-05
5	3	2.63459	9.64671	9.65765D-06	0.0	-1.72016D-05
6	3	3.00000	9.53539	1.29079D-05	0.0	-1.17325D-05
1	4	0.00000	10.08000	0.0	0.0	1.92918D-04
2	4	0.38068	10.07281	-1.76922D-04	0.0	-1.22791D-04
3	4	1.13986	10.01534	2.24224D-04	0.0	-5.24460D-05
4	4	1.89255	9.90074	1.66958D-03	0.0	-5.14134D-04
5	4	2.63443	9.72965	4.05929D-03	0.0	-1.22641D-03
6	4	3.00000	9.62322	4.97283D-03	0.0	-1.77436D-03
1	5	0.00000	10.16000	0.0	0.0	4.34669D-05
2	5	0.38059	10.15287	-1.71612D-04	0.0	6.00321D-05
3	5	1.13962	10.09588	1.87328D-04	0.0	-2.54457D-04
4	5	1.89226	9.98223	1.65433D-03	0.0	-7.19660D-04
5	5	2.63428	9.81255	3.79025D-03	0.0	-1.64636D-03
6	5	3.00000	9.70699	5.50848D-03	0.0	-2.30552D-03
1	6	0.00000	10.24000	0.0	0.0	1.58309D-04
2	6	0.38050	10.23293	-2.79701D-05	0.0	6.11515D-05
3	6	1.13938	10.17641	-4.13773D-06	0.0	-2.84539D-04
4	6	1.89198	10.06370	1.63486D-05	0.0	-6.19007D-04
5	6	2.63413	9.89540	1.46751D-05	0.0	-8.62069D-04
6	6	3.00000	9.79069	2.69064D-06	0.0	-9.50350D-04
1	7	0.00000	10.39000	0.0	0.0	1.54344D-04
2	7	0.38033	10.38304	2.74231D-05	0.0	4.95618D-05
3	7	1.13896	10.32738	5.97573D-05	0.0	-2.98476D-04
4	7	1.89148	10.21638	6.69339D-05	0.0	-6.31065D-04
5	7	2.63386	10.05062	5.20182D-05	0.0	-8.68651D-04
6	7	3.00000	9.94747	3.41156D-05	0.0	-9.53326D-04
1	8	0.00000	10.54000	0.0	0.0	1.24277D-04
2	8	0.38017	10.53314	8.16004D-05	0.0	2.97904D-05
3	8	1.13855	10.47833	1.23335D-04	0.0	-3.14583D-04
4	8	1.89099	10.36898	1.18494D-04	0.0	-6.43843D-04
5	8	2.63360	10.20567	9.22959D-05	0.0	-8.76297D-04
6	8	3.00000	10.10404	6.99633D-05	0.0	-9.57337D-04

DISPLACEMENTS FOR ASYMMETRIC LOADING MODE = 0

I	J	R-COORDINATE	Z-COORDINATE	R-DISPLACEMENT	THETA-DISPLACEMENT	Z-DISPLACEMENT
1	9	0.00000	10.62000	0.0	0.0	4.06384D-04
2	9	0.36009	10.61320	-4.36095D-04	0.0	2.55150D-05
3	9	1.13834	10.55882	-7.56191D-04	0.0	-1.52729D-04
4	9	1.89074	10.45033	5.05944D-04	0.0	-8.55616D-04
5	9	2.63346	10.28831	4.39153D-03	0.0	-2.19757D-03
6	9	3.00000	10.18746	6.71519D-03	0.0	-3.33858D-03
1	10	0.00000	10.70000	0.0	0.0	3.03300D-04
2	10	0.38002	10.69325	-4.99179D-04	0.0	3.87342D-04
3	10	1.13813	10.63930	-8.50515D-04	0.0	-2.31415D-04
4	10	1.89050	10.53167	4.34901D-04	0.0	-1.00560D-03
5	10	2.63333	10.37090	3.84317D-03	0.0	-2.85236D-03
6	10	3.00000	10.27083	7.19051D-03	0.0	-4.27392D-03
1	11	0.00000	10.78000	0.0	0.0	5.73492D-04
2	11	0.37994	10.77330	-5.32306D-05	0.0	4.17653D-04
3	11	1.13793	10.71977	-6.26452D-05	0.0	-2.33699D-04
4	11	1.89026	10.61298	-1.38392D-04	0.0	-1.12357D-03
5	11	2.63321	10.45345	-2.95732D-04	0.0	-2.15085D-03
6	11	3.00000	10.35415	-4.13560D-04	0.0	-2.66715D-03
1	12	0.00000	10.93000	0.0	0.0	5.74276D-04
2	12	0.37980	10.92340	4.48255D-05	0.0	4.07342D-04
3	12	1.13756	10.87064	5.92053D-05	0.0	-2.45713D-04
4	12	1.88983	10.76538	5.17427D-05	0.0	-1.13277D-03
5	12	2.63258	10.60813	-8.76111D-05	0.0	-2.15424D-03
6	12	3.00000	10.51023	-2.00911D-04	0.0	-2.66017D-03
1	13	0.00000	11.08000	0.0	0.0	5.28806D-04
2	13	0.37967	11.07349	1.40306D-04	0.0	3.77958D-04
3	13	1.13721	11.02149	2.37137D-04	0.0	-2.68950D-04
4	13	1.88942	10.91771	2.38057D-04	0.0	-1.14935D-03
5	13	2.63275	10.76267	1.20056D-04	0.0	-2.16416D-03
6	13	3.00000	10.66613	1.48605D-05	0.0	-2.67396D-03
1	14	0.00000	11.16000	0.0	0.0	9.16357D-04
2	14	0.37960	11.15354	9.42639D-05	0.0	1.09742D-04
3	14	1.13703	11.10193	4.23842D-04	0.0	-1.66361D-04
4	14	1.88921	10.99893	2.59719D-04	0.0	-1.27264D-03
5	14	2.63264	10.84504	7.02606D-03	0.0	-4.31941D-03
6	14	3.00000	10.74921	2.14882D-02	0.0	-1.15422D-02
1	15	0.00000	11.24000	0.0	0.0	4.18000D-04
2	15	0.37953	11.23359	9.47947D-05	0.0	2.98308D-04
3	15	1.13686	11.18236	5.32876D-04	0.0	-4.32313D-04
4	15	1.88900	11.08013	3.21595D-04	0.0	-1.07099D-03
5	15	2.63253	10.92737	1.15157D-02	0.0	-7.63527D-03
6	15	3.00000	10.83225	3.13503D-02	0.0	-2.08217D-02
1	16	0.00000	11.32000	0.0	0.0	2.91665D-04
2	16	0.37946	11.31364	1.72936D-04	0.0	2.73956D-04
3	16	1.13668	11.26279	5.51650D-04	0.0	-5.57912D-04
4	16	1.88880	11.16131	5.42693D-04	0.0	-1.02496D-03
5	16	2.63242	11.00967	1.29243D-02	0.0	-1.08945D-02
6	16	3.00000	10.91524	3.40528D-02	0.0	-2.85478D-02

MODE = 0

I	J	R	Z / ENERGY DENSITY	STRESSES RADIAL R	HOOP THETA	AXIAL Z	STRAINS SHEAR R-Z	SHEAR R-T	SHEAR Z-T
1	1	0.273	9.248	-3.290430 01	-3.307180 01	-7.764710 01	1.003260-01	0.0	0.0
			0.0	2.790580-07	6.132320-08	-5.788660-05	2.608470-07	0.0	0.0
2	1	0.865	9.239	-2.992560 01	-3.078780 01	-7.451270 01	1.460870 00	0.0	0.0
			0.0	1.534200-06	4.134230-07	-5.642900-05	3.798270-06	0.0	0.0
3	1	1.504	9.219	-2.434560 01	-2.572880 01	-6.524880 01	4.548740 00	0.0	0.0
			0.0	2.759440-06	9.611890-07	-5.041480-05	1.182670-05	0.0	0.0
4	1	2.141	9.187	-1.615820 01	-1.768760 01	-4.782490 01	8.600710 00	0.0	0.0
			0.0	3.316700-06	1.328500-06	-3.785010-05	2.236180-05	0.0	0.0
5	1	2.729	9.151	-9.402890 00	-1.128090 01	-3.260590 01	1.156280 01	0.0	0.0
			0.0	3.817270-06	1.375890-06	-2.634670-05	3.006320-05	0.0	0.0
1	2	0.218	9.746	-3.525850 01	-3.380370 01	-7.605080 01	-1.172670 00	0.0	0.0
			0.0	-2.021930-06	-7.868120-08	-5.499990-05	-3.048930-06	0.0	0.0
2	2	0.796	9.721	-3.266140 01	-3.268170 01	-7.531770 01	-2.262070 00	0.0	0.0
			0.0	-4.357430-08	-6.999150-08	-5.549670-05	-5.881390-06	0.0	0.0
3	2	1.512	9.658	-2.486410 01	-2.660890 01	-6.701160 01	-9.934260-01	0.0	0.0
			0.0	3.170370-06	9.021190-07	-5.162170-05	-2.582910-06	0.0	0.0
4	2	2.223	9.554	-1.142610 01	-1.553500 01	-4.848650 01	2.731240 00	0.0	0.0
			0.0	7.629750-06	2.288110-06	-4.054870-05	7.101230-06	0.0	0.0
5	2	2.788	9.448	-1.224870 00	-4.446660 00	-2.448570 01	4.594960 00	0.0	0.0
			0.0	7.687220-06	3.498640-06	-2.255190-05	1.194690-05	0.0	0.0
1	3	0.190	10.036	-7.388120 01	-7.384650 01	-7.360220 01	-1.487470-01	0.0	0.0
			0.0	-2.554820-04	-8.197330-05	1.139390-03	-1.487460-03	0.0	0.0
2	3	0.760	10.004	-7.404860 01	-7.412140 01	-7.419960 01	3.483350-02	0.0	0.0
			0.0	2.884090-04	-7.555370-05	-4.164130-04	3.498320-04	0.0	0.0
3	3	1.516	9.918	-6.936700 01	-6.991090 01	-7.053000 01	1.099280 00	0.0	0.0
			0.0	2.757470-03	1.380030-04	-2.957240-03	1.099280-02	0.0	0.0
4	3	2.264	9.774	-4.426610 01	-4.611610 01	-4.825860 01	3.200910 00	0.0	0.0
			0.0	9.688870-03	4.389710-04	-1.027430-02	3.200890-02	0.0	0.0
5	3	2.817	9.635	-1.058810 01	-1.385000 01	-1.756200 01	4.807850 00	0.0	0.0
			0.0	1.705170-02	7.423350-04	-1.781750-02	4.807820-02	0.0	0.0
1	4	0.190	10.116	-7.346440 01	-7.345550 01	-7.333120 01	-3.561330-02	0.0	0.0
			0.0	-4.572190-04	-4.126480-04	2.089960-04	-3.561350-04	0.0	0.0

MODE = 0

I	J	R	Z ENERGY DENSITY	RADIAL R	HOOP THETA	STRESSES / STRAINS AXIAL Z	SHEAR R-Z	SHEAR R-T	SHEAR Z-T
2	4	0.760	10.084	-7.446500D 01	-7.455800D 01	-7.458700D 01	-3.665150D-02	0.0	0.0
			0.0	4.856430D-04	2.096720D-05	-1.244210D-04	-3.665130D-04	0.0	0.0
3	4	1.516	9.999	-6.885600D 01	-6.915050D 01	-6.977710D 01	-1.312770D-01	0.0	0.0
			0.0	1.986920D-03	6.143000D-04	-2.518470D-03	-1.312760D-03	0.0	0.0
4	4	2.263	9.856	-4.690420D 01	-4.716430D 01	-4.619750D 01	-3.709220D-01	0.0	0.0
			0.0	2.652900D-03	1.253600D-03	-3.215160D-03	-3.709190D-03	0.0	0.0
5	4	2.617	9.718	-1.336750D 01	-1.388530D 01	-1.534120D 01	-1.708400D-01	0.0	0.0
			0.0	4.060500D-03	1.571350D-03	-5.707630D-03	-1.708390D-03	0.0	0.0
4	14	2.261	10.963	-4.552850D 01	-4.375020D 01	-5.292640D 01	1.752650D 00	0.0	0.0
			0.0	1.784140D-02	1.732620D-03	-1.914610D-02	1.752640D-02	0.0	0.0
5	14	2.616	10.838	-1.822390D 01	-3.089110D 01	-4.706920D 01	3.931260D 00	0.0	0.0
			0.0	6.921400D-02	5.928540D-03	-7.490160D-02	3.931230D-02	0.0	0.0
1	15	0.190	11.277	-4.969290D 01	-4.970960D 01	-4.995300D 01	2.912960D-02	0.0	0.0
			0.0	3.609600D-04	2.776290D-04	-9.393940D-04	2.912940D-04	0.0	0.0
2	15	0.756	11.248	-4.977960D 01	-4.980420D 01	-5.008140D 01	-4.905500D-02	0.0	0.0
			0.0	5.800260D-04	4.571230D-04	-9.287300D-04	-4.905470D-04	0.0	0.0
3	15	1.513	11.172	-4.966030D 01	-4.963120D 01	-4.973640D 01	6.877390D-02	0.0	0.0
			0.0	5.503660D-05	3.004290D-04	-4.652230D-04	6.877340D-04	0.0	0.0
4	15	2.261	11.045	-4.458740D 01	-4.763230D 01	-5.211930D 01	-5.076570D-01	0.0	0.0
			0.0	1.790410D-02	2.660010D-03	-1.975500D-02	-5.076540D-03	0.0	0.0
5	15	2.616	10.921	-1.892660D 01	-2.978540D 01	-4.525650D 01	-3.510060D 00	0.0	0.0
			0.0	6.214700D-02	7.654380D-03	-6.950030D-02	-3.510040D-02	0.0	0.0

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PROG S3359          SAMPLE PROBLEM 2.     FIRST HARMONIC                          DATE  8/20/75 TIME C6:57  PAGE      1
                                               *** GENERAL DATA ***

                                          THE GENERAL INPUT VALUES INPUT ARE:
      1.CCOOOOOCCOOO            1.0CCOOOOOOOCO           6.00000000C00             16.COOCOOOOCO
      C.0                       0.0                      0.C                       0.0
      0.0                       0.0                      1.00000000C00             1.0COOOOOCOCO
       THE GENERAL DATA VALLES ARE:
           IMIN                     1
           JMIN                     1
           IMAX                     6
           JMAX                     16
     BASE TEMPERATURE =     0.0     MODE =    1  MAX MODE =    1

PROG S3359          SAMPLE PROBLEM 2.     FIRST HARMONIC                          DATE  8/20/75 TIME 06:57  PAGE      7
                                          BOUNDARY CONDITION RECORDS
                             X CR R          THETA            Y OR Z             ROTATION           SLIDING
    I1   J1   I2   J2  CODE    VALUE      COCE   VALUE      CODE   VALUE      CODE   VALUE      CODE   VALUE      II   JJ

     1    1    6    1     1  C.C           1  C.C          1  0.0            0  C.0            0  0.0           1    1


PROG S3359          SAMPLE PROBLEM 2.     FIRST HARMONIC                          CATE  8/20/75 TIME C6:57  PAGE      8

                                                PRESSURE RECORDS

   I1    J1    I2    J2  ICO     P1        P2        S1        S2        PR1       PR2       PTH1      PTH2      PZ1       PZ2

    6     1     6    16   0    10C.0C    100.C0     0.0       0.0       0.0       0.0       0.0       0.C       0.C       0.C


PROG S3359          SAMPLE PROBLEM 2.     FIRST HARMONIC                          CATE  8/20/75 TIME C6:57  PAGE     10
        ACCUMLATION CONTRCL RECORDS
           FLAG                           THETA  CR  Z

           1.C                             C.C

PROG S3359          SAMPLE PROBLEM 2.     FIRST HARMONIC                          DATE  8/20/75 TIME C6:57  PAGE     11
                                                     GEOMETRY PLOTS
  IFLG  MIN  MAX    DISPM     SCALE      MIN       MAX       SIZE      TITLE    TITL             PLOT TITLE
        I/J  I/J              X/Y        X/Y       X/Y       X/Y       X/Y      SIZE

   2     1    6     5.CCO     2.CCC     8.000     0.0CO     0.000     2.0CO    0.12    SAMPLE 2  DEFORMEC 5X
         1   16               2.CCO    -1.000     0.0CO     G.000     8.3CO
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PROG S3359 SAMPLE PROBLEM 2, FIRST HARMONIC DATE 8/20/75 TIME 08:57 PAGE 14

DISPLACEMENTS FOR ASYMMETRIC LOADING MODE = 1

I	J	R-COORDINATE	Z-COORDINATE	R-DISPLACEMENT	THETA-DISPLACEMENT	Z-DISPLACEMENT
1	1	0.00000	9.00000	0.0	0.0	0.0
2	1	0.60000	9.00000	0.0	0.0	0.0
3	1	1.20000	9.00000	0.0	0.0	0.0
4	1	1.80000	9.00000	0.0	0.0	0.0
5	1	2.40000	9.00000	0.0	0.0	0.0
6	1	3.00000	9.00000	0.0	0.0	0.0
1	2	0.00000	9.50000	-4.83377D-05	4.82683D-05	-3.53065D-06
2	2	0.49109	9.49203	-5.00926D-05	4.83193D-05	1.36273D-05
3	2	1.17013	9.46451	-5.96403D-05	5.08659D-05	2.16523D-05
4	2	1.84635	9.41250	-7.14999D-05	5.02109D-05	1.65836D-05
5	2	2.51791	9.33629	-8.08306D-05	4.13015D-05	4.38439D-06
6	2	3.00000	9.26970	-9.95515D-05	2.71591D-05	4.49325D-05
1	3	0.00000	10.00000	-1.14583D-04	1.14495D-04	5.18008D-07
2	3	0.38077	9.99275	-1.13270D-04	1.12717D-04	2.44563D-05
3	3	1.14011	9.93479	-1.11772D-04	1.10655D-04	4.98736D-05
4	3	1.89284	9.81922	-1.21028D-04	1.01196D-04	4.00198D-05
5	3	2.63459	9.64671	-1.53316D-04	7.90126D-05	2.62568D-05
6	3	3.00000	9.53939	-1.68133D-04	5.67098D-05	7.21751D-05
1	4	0.00000	10.08000	-3.19279D-02	3.12274D-02	-2.74041D-03
2	4	0.36068	10.07281	-3.19053D-02	3.05527D-02	2.80744D-03
3	4	1.13986	10.01534	-3.33523D-02	3.19136D-02	2.60362D-03
4	4	1.89255	9.90074	-3.70075D-02	3.29387D-02	8.33542D-03
5	4	2.63443	9.72965	-4.21117D-02	3.43567D-02	1.07104D-02
6	4	3.00000	9.62322	-4.65076D-02	2.88110D-02	1.64944D-02
1	5	0.00000	10.16000	-6.72804D-02	6.67290D-02	-2.30264D-03
2	5	0.38059	10.15287	-6.56914D-02	6.49229D-02	3.94472D-03
3	5	1.13962	10.09586	-6.79933D-02	6.60880D-02	6.84413D-03
4	5	1.89226	9.98223	-6.99697D-02	6.66058D-02	1.50256D-02
5	5	2.63428	9.81255	-7.59377D-02	6.74573D-02	2.08373D-02
6	5	3.00000	9.70699	-7.82284D-02	6.16779D-02	2.75975D-02
1	6	0.00000	10.24000	-1.03374D-01	1.03372D-01	-1.26217D-06
2	6	0.38050	10.23293	-1.03263D-01	1.03273D-01	3.62979D-03
3	6	1.13938	10.17641	-1.02643D-01	1.02588D-01	1.18359D-02
4	6	1.89198	10.06370	-1.01401D-01	1.01260D-01	2.01533D-02
5	6	2.63413	9.89540	-9.95022D-02	9.93042D-02	2.86598D-02
6	6	3.00000	9.79069	-9.82807D-02	9.80946D-02	3.29511D-02
1	7	0.00000	10.39000	-1.04899D-01	1.04900D-01	-6.57630D-06
2	7	0.38033	10.38304	-1.04835D-01	1.04824D-01	3.83358D-03
3	7	1.13696	10.32738	-1.04288D-01	1.04182D-01	1.18455D-02
4	7	1.89148	10.21638	-1.03130D-01	1.02908D-01	2.01638D-02
5	7	2.63386	10.05062	-1.01304D-01	1.01010D-01	2.86674D-02
6	7	3.00000	9.94747	-1.00123D-01	9.98309D-02	3.29467D-02
1	8	0.00000	10.54000	-1.06423D-01	1.06425D-01	-2.46397D-06
2	8	0.38017	10.53314	-1.06403D-01	1.06370D-01	3.84490D-03
3	8	1.13855	10.47833	-1.05926D-01	1.05770D-01	1.18622D-02
4	8	1.89099	10.36898	-1.04651D-01	1.04550D-01	2.01806D-02
5	8	2.63360	10.20567	-1.03099D-01	1.02709D-01	2.86793D-02
6	8	3.00000	10.10404	-1.01957D-01	1.01557D-01	3.29550D-02

DISPLACEMENTS FOR ASYMMETRIC LOADING MODE = 1

I	J	R-COORDINATE	Z-COORDINATE	R-DISPLACEMENT	THETA-DISPLACEMENT	Z-DISPLACEMENT
1	9	0.00000	10.62000	-1.24549D-01	1.24170D-01	-1.05275D-03
2	9	0.38009	10.61320	-1.24122D-01	1.23324D-01	5.37546D-03
3	9	1.13834	10.55882	-1.23904D-01	1.23302D-01	1.30009D-02
4	9	1.89074	10.45033	-1.25703D-01	1.22807D-01	2.46129D-02
5	9	2.63346	10.28831	-1.30310D-01	1.22265D-01	3.52546D-02
6	9	3.00000	10.18746	-1.33831D-01	1.18709D-01	4.39285D-02
1	10	0.00000	10.70000	-1.44476D-01	1.44184D-01	-1.11883D-03
2	10	0.38002	10.69325	-1.43168D-01	1.42706D-01	5.72008D-03
3	10	1.13813	10.63930	-1.43318D-01	1.42552D-01	1.52463D-02
4	10	1.89050	10.53167	-1.44191D-01	1.41769D-01	2.81612D-02
5	10	2.63333	10.37090	-1.48851D-01	1.40904D-01	4.10360D-02
6	10	3.00000	10.27083	-1.52129D-01	1.37266D-01	5.00324D-02
1	11	0.00000	10.78000	-1.64712D-01	1.64708D-01	-5.60831D-06
2	11	0.37994	10.77330	-1.64497D-01	1.64536D-01	5.63265D-03
3	11	1.13793	10.71977	-1.63493D-01	1.63489D-01	1.78138D-02
4	11	1.89026	10.61298	-1.61553D-01	1.61521D-01	3.08715D-02
5	11	2.63321	10.45345	-1.58667D-01	1.58677D-01	4.44373D-02
6	11	3.00000	10.35415	-1.56844D-01	1.56937D-01	5.12514D-02
1	12	0.00000	10.93000	-1.66941D-01	1.66942D-01	-1.65432D-05
2	12	0.37980	10.92340	-1.66846D-01	1.66527D-01	5.62851D-03
3	12	1.13756	10.87064	-1.66031D-01	1.65862D-01	1.78131D-02
4	12	1.88983	10.76536	-1.64278D-01	1.64032D-01	3.08732D-02
5	12	2.63298	10.60813	-1.61513D-01	1.61298D-01	4.44392D-02
6	12	3.00000	10.51023	-1.59737D-01	1.59605D-01	5.12460D-02
1	13	0.00000	11.08000	-1.69168D-01	1.69175D-01	-6.00600D-06
2	13	0.37967	11.07345	-1.69188D-01	1.69113D-01	5.64070D-03
3	13	1.13721	11.02149	-1.68555D-01	1.68207D-01	1.78326D-02
4	13	1.88942	10.91771	-1.66987D-01	1.66533D-01	3.08868D-02
5	13	2.63275	10.76267	-1.64349D-01	1.63909D-01	4.44510D-02
6	13	3.00000	10.66613	-1.62630D-01	1.62261D-01	5.12605D-02
1	14	0.00000	11.16000	-1.70412D-01	1.70371D-01	-3.05502D-04
2	14	0.37960	11.15354	-1.70362D-01	1.70370D-01	6.10528D-03
3	14	1.13703	11.10193	-1.70136D-01	1.69580D-01	1.76291D-02
4	14	1.88921	10.99893	-1.68233D-01	1.68087D-01	3.11014D-02
5	14	2.63264	10.84504	-1.79430D-01	1.66777D-01	4.87473D-02
6	14	3.00000	10.74921	-2.06883D-01	1.64537D-01	6.09560D-02
1	15	0.00000	11.24000	-1.71786D-01	1.71775D-01	5.47316D-05
2	15	0.37953	11.23359	-1.71558D-01	1.71617D-01	5.65247D-03
3	15	1.13686	11.18236	-1.71566D-01	1.70884D-01	1.61360D-02
4	15	1.88900	11.08013	-1.69571D-01	1.69552D-01	3.06592D-02
5	15	2.63253	10.92737	-1.89681D-01	1.69238D-01	5.53324D-02
6	15	3.00000	10.83225	-2.27919D-01	1.66353D-01	6.71479D-02
1	16	0.00000	11.32000	-1.72927D-01	1.72963D-01	5.97922D-05
2	16	0.37946	11.31364	-1.72899D-01	1.72357D-01	5.61248D-03
3	16	1.13668	11.26279	-1.72800D-01	1.72176D-01	1.63604D-02
4	16	1.88880	11.16131	-1.71247D-01	1.70920D-01	3.05220D-02
5	16	2.63242	11.00967	-1.93788D-01	1.71223D-01	6.17824D-02
6	16	3.00000	10.91524	-2.34647D-01	1.69170D-01	1.03522D-01

PROG S3359 SAMPLE PROBLEM 2, FIRST HARMONIC DATE 8/20/75 TIME 08:57 PAGE 16

MODE = 1

I	J	R / ENERGY DENSITY	Z	STRESSES RADIAL R / STRAINS	HOOP THETA	AXIAL Z	SHEAR R-Z	SHEAR R-T	SHEAR Z-T
1	1	0.273	9.248	5.92644D 00	7.16117D 00	2.09553D 01	-3.32178D 01	6.41178D-01	3.63213D 01
		0.0		-2.71399D-06	-1.11144D-06	1.68210D-05	-8.63662D-05	2.18706D-06	9.44353D-05
2	1	0.865	9.239	7.25736D 00	1.31794D 01	4.34801D 01	-4.17428D 01	2.34734D 00	3.68524D 01
		0.0		-9.72658D-06	-2.02795D-06	3.73630D-05	-1.08531D-04	6.10309D-06	9.53163D-05
3	1	1.504	9.219	1.37231D 00	1.02806D 01	4.68068D 01	-5.80010D 01	3.01332D 00	4.18177D 01
		0.0		-1.52916D-05	-3.71084D-06	4.37733D-05	-1.50802D-04	7.63463D-06	1.08726D-04
4	1	2.141	9.187	-1.36385D 01	-2.72586D 00	2.44915D 01	-7.94894D 01	2.20268D 00	4.56548D 01
		0.0		-1.95423D-05	-5.35583D-06	3.00268D-05	-2.00672D-04	5.72745D-06	1.19222D-04
5	1	2.729	9.151	-1.46857D 01	1.27134D 01	6.63815D 01	-9.79312D 01	-2.61855D-01	4.29425D 01
		0.0		-4.20255D-05	-6.40663D-06	8.93619D-05	-2.54621D-04	-6.80823D-07	1.11651D-04
1	2	0.218	9.746	5.14112D 00	4.22721D 00	2.09654D 01	-3.25872D 01	1.70865D 00	3.72202D 01
		0.0		-2.79013D-06	-3.97821D-06	1.77814D-05	-8.47267D-05	4.44248D-06	9.67726D-05
2	2	0.796	9.721	6.97523D 00	1.25682D 01	4.99419D 01	-3.66338D 01	5.19025D 00	3.76261D 01
		0.0		-1.28242D-05	-5.55327D-06	4.30325D-05	-9.53779D-05	1.34947D-05	9.78278D-05
3	2	1.512	9.658	-9.02274D 00	6.45640D 00	5.51419D 01	-4.57057D 01	6.11390D 00	4.03869D 01
		0.0		-2.83150D-05	-8.19210D-06	5.89991D-05	-1.18835D-04	1.58961D-05	1.05011D-04
4	2	2.223	9.554	-5.01101D 01	-1.69303D 01	4.44168D 01	-6.30703D 01	5.56103D 00	4.40361D 01
		0.0		-5.78223D-05	-1.46885D-05	6.50628D-05	-1.63983D-04	1.44587D-05	1.14494D-04
5	2	2.786	9.448	-9.81458D 01	-4.81457D 01	2.30235D 01	-4.20170D 01	1.95274D 00	4.09007D 01
		0.0		-9.02045D-05	-2.52047D-05	6.73156D-05	-1.09244D-04	5.07712D-06	1.06342D-04
1	3	0.190	10.036	1.81544D 01	1.88769D 01	1.97112D 01	-3.90066D 01	1.02959D 00	3.90911D 01
		0.0		-7.50612D-03	-3.89394D-03	2.77426D-04	-3.90064D-01	1.02959D-02	3.90909D-01
2	3	0.760	10.004	3.36510D 01	3.96946D 01	4.60438D 01	-4.02588D 01	3.18721D 00	3.85778D 01
		0.0		-3.17342D-02	-1.51621D-03	3.32294D-02	-4.02585D-01	3.18719D-02	3.85776D-01
3	3	1.516	9.918	4.78614D 01	6.14563D 01	7.50291D 01	-4.18940D 01	6.24528D 00	3.97963D 01
		0.0		-6.86380D-02	-7.64093D-04	6.70992D-02	-4.18937D-01	6.24524D-02	3.97961D-01
4	3	2.264	9.774	-1.19538D 01	1.07572D 01	3.40687D 01	-4.51479D 01	9.65487D 00	4.00468D 01
		0.0		-1.14586D-01	-1.03198D-03	1.15523D-01	-4.51476D-01	9.65481D-02	4.00465D-01
5	3	2.817	9.635	-6.93951D 01	-3.75264D 01	-4.71676D 00	-4.74058D 01	1.04484D 01	3.76117D 01
		0.0		-1.60672D-01	-1.52937D-03	1.62516D-01	-4.74054D-01	1.04463D-01	3.76114D-01
1	4	0.190	10.116	1.09569D 01	1.08947D 01	1.41290D 01	-4.16277D 01	1.12746D 00	4.34755D 01
		0.0		-6.00945D-03	-6.32075D-03	5.85085D-03	-4.16275D-01	1.12745D-02	4.34752D-01

MODE = 1

I	J	R	Z	ENERGY DENSITY	RADIAL R	HOOP THETA	STRESSES / STRAINS AXIAL Z	SHEAR R-Z	SHEAR R-T	SHEAR Z-T
2	4	0.760	10.084		3.658060D 01	4.347540D 01	5.060590D 01	-4.218510D 01	3.596360D 00	4.222670D 01
				0.0	-3.455460D-02	-2.120860D-03	3.353130D-02	-4.218480D-01	3.596330D-02	4.222640D-01
3	4	1.516	9.599		4.209150D 01	5.508110D 01	6.901270D 01	-3.979150D 01	6.662460D 00	4.137400D 01
				0.0	-6.703270D-02	-2.085280D-03	6.757230D-02	-3.979120D-01	6.662420D-02	4.137380D-01
4	4	2.263	9.856		-1.240680D 00	1.842480D 01	3.941470D 01	-3.775130D 01	9.734900D 00	4.006640D 01
				0.0	-1.008230D-01	-2.496620D-03	1.024520D-01	-3.775110D-01	9.734830D-02	4.006620D-01
5	4	2.817	9.718		-7.554170D 01	-5.181550D 01	-2.541610D 01	-3.393320D 01	1.038600D 01	3.892660D 01
				0.0	-1.231990D-01	-4.568430D-03	1.274280D-01	-3.393300D-01	1.038590D-01	3.892630D-01
1	15	0.190	11.277		-1.227090D-01	-9.273260D-02	-1.297250D-01	-8.628400D-02	-3.188860D-02	5.187660D-03
				0.0	7.576070D-05	2.256420D-04	4.068170D-05	-8.628350D-04	-3.188840D-04	5.187630D-05
2	15	0.758	11.248		-2.920980D-01	-1.383460D-01	1.856910D-01	6.965690D-02	5.625790D-02	8.651230D-03
				0.0	-1.021410D-03	-4.520550D-04	1.167520D-03	6.965640D-04	5.625750D-04	8.651170D-05
3	15	1.513	11.172		-5.987640D-01	-6.291240D-01	-4.707090D-01	-1.528570D-01	7.406560D-02	2.764660D-02
				0.0	-8.065450D-05	-2.324950D-04	5.595750D-04	-1.528560D-03	7.406530D-04	2.764640D-04
4	15	2.261	11.045		-1.067810D 01	-4.409010D 00	4.275390D 00	1.008000D 00	8.790730D-01	1.387080D-01
				0.0	-3.594080D-02	-4.595540D-03	3.882610D-02	1.007990D-02	8.790670D-03	1.387080D-03
5	15	2.816	10.921		-6.205720D 01	-4.011350D 01	-9.495240D 00	7.007540D 00	1.547760D 00	-5.344130D-04
				0.0	-1.245200D-01	-1.480280D-02	1.382870D-01	7.007490D-02	1.547690D-02	-5.344090D-04

COORDINATES AND DISPLACEMENTS FOR THETA = 0.0

NODAL	PT	COORDINATES		DISPLACEMENTS U	V	W
1	1	0.0000	9.0000	0.0	0.0	0.0
2	1	0.6000	9.0000	0.0	0.0	0.0
3	1	1.2000	9.0000	0.0	0.0	0.0
4	1	1.8000	9.0000	0.0	0.0	0.0
5	1	2.4000	9.0000	0.0	0.0	0.0
6	1	3.0000	9.0000	0.0	0.0	0.0
1	2	0.0000	9.5000	-4.83377E-05	0.0	-2.89265E-05
2	2	0.4911	9.4920	-4.98132E-05	0.0	-1.48845E-05
3	2	1.1701	9.4645	-5.74459E-05	0.0	-3.89627E-06
4	2	1.8464	9.4125	-6.62234E-05	0.0	-1.88291E-06
5	2	2.5179	9.3363	-7.27165E-05	0.0	-4.53648E-06
6	2	3.0000	9.2657	-8.58166E-05	0.0	3.79484E-05
1	3	0.0000	10.0000	-1.14583E-04	0.0	-5.56674E-05
2	3	0.3808	9.9927	-1.15088E-04	0.0	-3.17416E-05
3	3	1.1461	9.9348	-1.14980E-04	0.0	-2.13839E-06
4	3	1.8528	9.8192	-1.20798E-04	0.0	2.98755E-06
5	3	2.6346	9.6467	-1.43659E-04	0.0	9.05527E-06
6	3	3.0000	9.5394	-1.55225E-04	0.0	6.04426E-05
1	4	0.0000	10.0800	-3.19279E-02	0.0	-2.54749E-03
2	4	0.3807	10.0728	-3.20823E-02	0.0	2.68464E-03
3	4	1.1359	10.0153	-3.31280E-02	0.0	2.55117E-03
4	4	1.8525	9.9007	-3.53380E-02	0.0	7.82128E-03
5	4	2.6344	9.7297	-3.80524E-02	0.0	9.46403E-03
6	4	3.0000	9.6232	-4.15348E-02	0.0	1.47201E-02
1	5	0.0000	10.1600	-6.72804E-02	0.0	-2.25915E-03
2	5	0.3806	10.1529	-6.58630E-02	0.0	4.00475E-03
3	5	1.1396	10.0959	-6.78059E-02	0.0	6.58967E-03
4	5	1.8523	9.9822	-6.63153E-02	0.0	1.43059E-02
5	5	2.6343	9.8126	-7.21474E-02	0.0	1.91910E-02
6	5	3.0000	9.7070	-7.27199E-02	0.0	2.52920E-02
1	6	0.0000	10.2400	-1.03374E-01	0.0	1.57046E-04
2	6	0.3805	10.2329	-1.03290E-01	0.0	3.85094E-03
3	6	1.1394	10.1764	-1.02647E-01	0.0	1.15513E-02
4	6	1.8520	10.0637	-1.01385E-01	0.0	1.95343E-02
5	6	2.6341	9.8954	-9.94874E-02	0.0	2.77977E-02
6	6	3.0000	9.7907	-9.82780E-02	0.0	3.20008E-02
1	7	0.0000	10.3900	-1.04899E-01	0.0	1.47768E-04
2	7	0.3803	10.3030	-1.04807E-01	0.0	3.88314E-03
3	7	1.1390	10.3274	-1.04229E-01	0.0	1.15470E-02
4	7	1.8515	10.2164	-1.03064E-01	0.0	1.95328E-02
5	7	2.6339	10.0566	-1.01252E-01	0.0	2.77588E-02
6	7	3.0000	9.9475	-1.00088E-01	0.0	3.19954E-02
1	8	0.0000	10.5400	-1.06423E-01	0.0	1.21813E-04
2	8	0.3802	10.5331	-1.06321E-01	0.0	3.87469E-03
3	8	1.1385	10.4783	-1.05803E-01	0.0	1.15476E-02
4	8	1.8510	10.3690	-1.04733E-01	0.0	1.95367E-02
5	8	2.6336	10.2057	-1.03007E-01	0.0	2.78030E-02
6	8	3.0000	10.1040	-1.01887E-01	0.0	3.19976E-02

COORDINATES AND DISPLACEMENTS FOR THETA = 0.0

NODAL	PT	COORDINATES		DISPLACEMENTS U	V	W
1	9	0.0000	10.6200	-1.24549E-01	0.0	-1.24637E-03
2	9	0.3801	10.6132	-1.24608E-01	0.0	5.40097E-03
3	9	1.1383	10.5988	-1.24660E-01	0.0	1.28481E-02
4	9	1.8907	10.4503	-1.25197E-01	0.0	2.37573E-02
5	9	2.6335	10.2883	-1.25918E-01	0.0	3.30572E-02
6	9	3.0000	10.1875	-1.27115E-01	0.0	4.01903E-02
1	10	0.0000	10.7000	-1.44476E-01	0.0	-8.15526E-04
2	10	0.3800	10.6932	-1.43687E-01	0.0	6.10742E-03
3	10	1.1381	10.6393	-1.44169E-01	0.0	1.50149E-02
4	10	1.8985	10.5317	-1.43757E-01	0.0	2.71556E-02
5	10	2.6333	10.3709	-1.45038E-01	0.0	3.81836E-02
6	10	3.0000	10.2708	-1.44938E-01	0.0	4.57584E-02
1	11	0.0000	10.7800	-1.64712E-01	0.0	5.07883E-04
2	11	0.3799	10.7733	-1.64550E-01	0.0	6.05033E-03
3	11	1.1379	10.7198	-1.63555E-01	0.0	1.75601E-02
4	11	1.8903	10.6130	-1.61691E-01	0.0	2.97479E-02
5	11	2.6332	10.4525	-1.58962E-01	0.0	4.22664E-02
6	11	3.0000	10.3541	-1.57254E-01	0.0	4.85243E-02
1	12	0.0000	10.9300	-1.60941E-01	0.0	5.57335E-04
2	12	0.3798	10.9234	-1.66802E-01	0.0	6.03585E-03
3	12	1.1376	10.8706	-1.65942E-01	0.0	1.75674E-02
4	12	1.8858	10.7654	-1.64226E-01	0.0	2.97404E-02
5	12	2.6330	10.6081	-1.61600E-01	0.0	4.22849E-02
6	12	3.0000	10.5102	-1.59937E-01	0.0	4.85619E-02
1	13	0.0000	11.0800	-1.69168E-01	0.0	5.22859E-04
2	13	0.3797	11.0735	-1.69048E-01	0.0	6.02470E-03
3	13	1.1372	11.0215	-1.68317E-01	0.0	1.75636E-02
4	13	1.8894	10.9177	-1.66749E-01	0.0	2.97395E-02
5	13	2.6328	10.7627	-1.64229E-01	0.0	4.22869E-02
6	13	3.0000	10.6661	-1.62615E-01	0.0	4.85865E-02
1	14	0.0000	11.1600	-1.70412E-01	0.0	1.10654E-04
2	14	0.3796	11.1535	-1.70268E-01	0.0	6.21502E-03
3	14	1.1370	11.1019	-1.69712E-01	0.0	1.74607E-02
4	14	1.8892	10.9909	-1.67974E-01	0.0	2.98288E-02
5	14	2.6326	10.8450	-1.72402E-01	0.0	4.44282E-02
6	14	3.0000	10.7492	-1.65395E-01	0.0	5.74434E-02
1	15	0.0000	11.2400	-1.71786E-01	0.0	4.72731E-04
2	15	0.3795	11.2336	-1.71464E-01	0.0	5.95046E-03
3	15	1.1369	11.1824	-1.71033E-01	0.0	1.77047E-02
4	15	1.8890	11.0801	-1.69250E-01	0.0	2.95693E-02
5	15	2.6325	10.9274	-1.78165E-01	0.0	4.70541E-02
6	15	3.0000	10.8322	-1.96568E-01	0.0	6.64962E-02
1	16	0.0000	11.3200	-1.72927E-01	0.0	3.91457E-04
2	16	0.3795	11.3136	-1.72726E-01	0.0	5.88696E-03
3	16	1.1367	11.2628	-1.72249E-01	0.0	1.78025E-02
4	16	1.8888	11.1613	-1.70704E-01	0.0	2.94970E-02
5	16	2.6324	11.0097	-1.80363E-01	0.0	5.08835E-02
6	16	3.0000	10.9152	-2.00594E-01	0.0	7.46740E-02

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NODAL PT                                       S T R E S S E S / S T R A I N S
COORDINATES                    R                THETA               Z              R-THETA              Z-THETA               R-Z

   1        1   STRESS   -0.2697583D 02   -0.2591059D 02   -0.5669173D 02    0.0               0.0                -0.3311745D 02
 0.27    9.25   STRAIN   -0.2434933D-05   -0.1050118D-05   -0.4106561D-04    0.0               0.0                -0.8610537D-04
H=   -0.1087788D-03                              P R I N C I P L E   V A L U E S
                STRESS   -0.5536065D 01   -0.2591059D 02   -0.7813150D 02    0.1018726D 02    0.3629772D 02     0.2611045D 02
                STRAIN    0.2543676D-04   -0.1050118D-05   -0.6893730D-04    0.2648688D-04    0.9437406D-04     0.6788718D-04

   2        1   STRESS   -0.2266827D 02   -0.1760839D 02   -0.3103257D 02    0.0               0.0                -0.4028191D 02
 0.87    9.24   STRAIN   -0.8192382D-05   -0.1614530D-05   -0.1906596D-04    0.0               0.0                -0.1047330D-03
H=   -0.7092126D-04                              P R I N C I P L E   V A L U E S
                STRESS    0.1364600D 02   -0.1760839D 02   -0.6734884D 02    0.1562820D 02    0.4049842D 02     0.2487023D 02
                STRAIN    0.3901878D-04   -0.1614530D-05   -0.6627712D-04    0.4063331D-04    0.1052959D-03     0.6466259D-04

   3        1   STRESS   -0.2297325D 02   -0.1544825D 02   -0.1844197D 02    0.0               0.0                -0.5345221D 02
 1.50    9.22   STRAIN   -0.1253214D-04   -0.2749654D-05   -0.6641487D-05    0.0               0.0                -0.1389757D-03
H=   -0.5777692D-04                              P R I N C I P L E   V A L U E S
                STRESS    0.3279259D 02   -0.1544825D 02   -0.7420781D 02    0.2412042D 02    0.5350020D 02     0.2937978D 02
                STRAIN    0.5996345D-04   -0.2749654D-05   -0.7913708D-04    0.6271310D-04    0.1391005D-03     0.7638742D-04

   4        1   STRESS   -0.2975665D 02   -0.2041341D 02   -0.2333334D 02    0.0               0.0                -0.7088868D 02
 2.14    9.19   STRAIN   -0.1622560D-04   -0.4027335D-05   -0.7823249D-05    0.0               0.0                -0.1843106D-03
H=   -0.7503366D-04                              P R I N C I P L E   V A L U E S
                STRESS    0.4439729D 02   -0.2041341D 02   -0.9752732D 02    0.3240535D 02    0.7096230D 02     0.3855696D 02
                STRAIN    0.8022657D-04   -0.4027335D-05   -0.1042754D-03    0.8425391D-04    0.1845020D-03     0.1002481D-03

   5        1   STRESS   -0.2408859D 02    0.1432526D 01    0.5377557D 02    0.0               0.0                -0.8636840D 02
 2.73    9.15   STRAIN   -0.3820819D-04   -0.5030734D-05    0.6301522D-04    0.0               0.0                -0.2245579D-03
H=    0.2297673D-04                              P R I N C I P L E   V A L U E S
                STRESS    0.1095811D 03    0.1432526D 01   -0.7989409D 02    0.5407427D 02    0.9473757D 02     0.4066331D 02
                STRAIN    0.1355624D-03   -0.5030734D-05   -0.1107553D-03    0.1405931D-03    0.2463177D-03     0.1057246D-03

   1        2   STRESS   -0.3015735D 02   -0.2957646D 02   -0.5508539D 02    0.0               0.0                -0.3373987D 02
 0.22    9.75   STRAIN   -0.4812056D-05   -0.4056891D-05   -0.3721850D-04    0.0               0.0                -0.8777567D-04
H=   -0.1146417D-03                              P R I N C I P L E   V A L U E S
                STRESS   -0.6634143D 01   -0.2957646D 02   -0.7860866D 02    0.1147116D 02    0.3598723D 02     0.2451607D 02
                STRAIN    0.2576812D-04   -0.4056891D-05   -0.6779868D-04    0.2982501D-04    0.9356680D-04     0.6374179D-04

   2        2   STRESS   -0.2568615D 02   -0.2011347D 02   -0.2537578D 02    0.0               0.0                -0.3894587D 02
 0.80    9.72   STRAIN   -0.1286775D-04   -0.5623265D-05   -0.1246426D-04    0.0               0.0                -0.1012593D-03
H=   -0.6641417D-04                              P R I N C I P L E   V A L U E S
                STRESS    0.1341522D 02   -0.2011347D 02   -0.6447714D 02    0.1676434D 02    0.3894618D 02     0.2218184D 02
                STRAIN    0.3796403D-04   -0.5623265D-05   -0.6329604D-04    0.4358730D-04    0.1012601D-03     0.5767278D-04
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PROG S3359          SAMPLE PROBLEM 2.      FIRST HARMONIC                                   DATE  8/20/75 TIME 08:57  PAGE      24
NODAL PT                                      S T R E S S E S / S T R A I N S
COORDINATES              R                    THETA              Z               R-THETA             Z-THETA             R-Z

  3        2   STRESS  -0.3388680D 02   -0.2015247D 02   -0.8869889D 01   0.0                 0.0                -0.4609911D 02
 1.51    9.66  STRAIN  -0.2514460D-04   -0.7285982D-05    0.7377378D-05   0.0                 0.0                -0.1214177D-03
H=    -0.6302746D-04                       P R I N C I P L E   V A L U E S
               STRESS   0.2696656D 02   -0.2015247D 02   -0.6972365D 02   0.2355972D 02       0.4834530D 02       0.2478555D 02
               STRAIN   0.5396528D-04   -0.7285982D-05   -0.7173251D-04   0.6125526D-04       0.1256978D-03       0.6444253D-04

  4        2   STRESS  -0.6153622D 02   -0.3246531D 02   -0.4069615D 01   0.0                 0.0                -0.6033904D 02
 2.22    9.55  STRAIN  -0.5019254D-04   -0.1240035D-04    0.2451405D-04   0.0                 0.0                -0.1568815D-03
H=    -0.9534853D-04                       P R I N C I P L E   V A L U E S
               STRESS   0.3402823D 02   -0.3246531D 02   -0.9963407D 02   0.3324677D 02       0.6683115D 02       0.3353430D 02
               STRAIN   0.7404126D-04   -0.1240035D-04   -0.9971974D-04   0.8644161D-04       0.1737610D-03       0.8731939D-04



  4       15   STRESS  -0.5526549D 02   -0.5204125D 02   -0.4764389D 02   0.0                 0.0                 0.5003416D 00
 2.26   11.04  STRAIN  -0.1803665D-01   -0.1915534D-02    0.1907115D-01   0.0                 0.0                 0.5003365D-02
H=    -0.5165883D 00                       P R I N C I P L E   V A L U E S
               STRESS  -0.4781031D 02   -0.5204125D 02   -0.5529907D 02   0.2115472D 01       0.3744334D 01       0.1628912D 01
               STRAIN   0.1923904D-01   -0.1915534D-02   -0.1820455D-01   0.2115458D-01       0.3744359D-01       0.1628901D-01

  5       15   STRESS  -0.8058400D 02   -0.6985891D 02   -0.5475171D 02   0.0                 0.0                 0.3497478D 01
 2.82   10.92  STRAIN  -0.6237346D-01   -0.6964419D-02    0.6878710D-01   0.0                 0.0                 0.3497455D-01
H=    -0.6851014D 00                       P R I N C I P L E   V A L U E S
               STRESS  -0.5429341D 02   -0.6985891D 02   -0.8144230D 02   0.7602753D 01       0.1357444D 02       0.5771692D 01
               STRAIN   0.7107655D-01   -0.6964419D-02   -0.6466495D-01   0.7602761D-01       0.1357435D 00       0.5771654D-01

   PLOT FOR     1      1      6     16   WITH X & Y SCALE FACTORS    2.0000000 00    2.0000000 00
        THE X & Y MINS & MAXS ARE      8.0000000 00   -1.0000000 00    1.9037950-77    1.9037950-77
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THIOKOL AUTOMATED STRESS SYSTEM

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10:58  ENTERED INPUT MODULE
     INPUT ROUTINE REQUIRED      3K BYTES.  ADDITIONAL STORAGE MAY BE REQUIRED BY WORKING ROUTINES.
     INPUT MODULE HAD    62 K AVAILABLE AND USED     6 K. EXCESS AVAILABLE WAS    56 K.
10:59  LEAVING INPUT MODULE.  CPU TIME      0.065 MINS., WAIT TIME     0.054 MINS.

10:59  ENTERED SOLUTION MODULE
     SOLUTION MODULE HAD    62 K AVAILABLE AND USED    13 K.  EXCESS AVAILABLE WAS    49 K.
11:01  LEAVING SOLUTION MODULE.  CPU TIME      1.146 MINS., WAIT TIME     0.058 MINS.

11:01  ENTERED STRESS MODULE
     STRESS MODULE HAD    62 K AVAILABLE AND USED     2 K.  EXCESS AVAILABLE WAS    61 K.
11:01  LEAVING STRESS MODULE.  CPU TIME      1.194 MINS., WAIT TIME     0.061 MINS.

11:01 ENTERED PRINT MODULE
     PRINT MODULE HAD    62 K AVAILABLE AND USED     1 K. EXCESS AVAILABLE WAS    61 K.
11:01  LEAVING PRINT MODULE.  CPU TIME      1.220 MINS., WAIT TIME     0.064 MINS.
```

THIOKOL AUTOMATED STRESS SYSTEM

```
11:01  ENTERED INPUT MODULE
     INPUT ROUTINE REQUIRED      3K BYTES.  ADDITIONAL STORAGE MAY BE REQUIRED BY WORKING ROUTINES.
     INPUT MODULE HAD    62 K AVAILABLE AND USED     7 K. EXCESS AVAILABLE WAS    55 K.
11:02  LEAVING INPUT MODULE.  CPU TIME      1.285 MINS., WAIT TIME     0.074 MINS.

11:02  ENTERED SOLUTION MODULE
     SOLUTION MODULE HAD    62 K AVAILABLE AND USED    13 K.  EXCESS AVAILABLE WAS    49 K.
11:04  LEAVING SOLUTION MODULE.  CPU TIME      2.504 MINS., WAIT TIME     0.077 MINS.

11:04  ENTERED STRESS MODULE
     STRESS MODULE HAD    62 K AVAILABLE AND USED     2 K.  EXCESS AVAILABLE WAS    61 K.
11:04  LEAVING STRESS MODULE.  CPU TIME      2.552 MINS., WAIT TIME     0.060 MINS.

11:04 ENTERED PRINT MODULE
     PRINT MODULE HAD    62 K AVAILABLE AND USED     1 K. EXCESS AVAILABLE WAS    61 K.
11:04  LEAVING PRINT MODULE.  CPU TIME      2.578 MINS., WAIT TIME     0.062 MINS.

11:04ENTERED PLOT/ACCUMULATION MODULE
     P/A MODULE HAD    62 K BYTES AVAILABLE AND USED     4 K BYTES.  EXCESS AVAILABLE WAS    58 K BYTES.
11:05  LEAVING PLOT/ACCUMULATION MODULE.  CPU TIME      2.634 MINS., WAIT TIME     0.089 MINS.
```

APPENDIX A

Service Life Program

This program is designated as S3359SL. It is designed to accept a tape or tapes created by S3359, when output option 20 has been specified, and accumulate a selected set of stresses and strains.

The energy is calculated for each element from the principal stresses and strains as the accumulation is done.

The accumulated energy, stresses and strains and the principal stresses and strains calculated from the accumulated stresses and strains are printed out at the end of the run. The locations of the highest energy and the highest value of the principal stresses are printed out also.

Input

When the S3359 runs were made, a pair of integers giving the date and time for each set of data put on the tape was written out. To select the desired sets of data from the tape for accumulation, the date and time of each of the desired sets must be input exactly as they were written out and in the same order as they appear on the tape.

The input is via FREFRM as follows:

Title - A title record that will be printed on the top of each page of the output. This must be only one card.

Control Records

As many records as desired to select the data sets.

L1	The data as printed by S3359.
L2	The time as printed by S3359.
L3	The factor by which the stresses and strains will be multiplied. The default value is 1.0.

An end of file stops the reading and accumulating and causes the final output to be produced.

APPENDIX B

S3359F Fourier Coefficient Generator

This program computes the Fourier series coefficients by use of Trapezoidal Integration Formula, then fits the function $f(\theta)$ with a Fourier series curve fit. The output includes a set of cards containing the Fourier series coefficients in a form compatible with the input requirements of program S3359.

The function to be fit with a Fourier series curve fit must be either odd or even having period 2π. The integration for the coefficients is performed over the interval $[0,\pi]$ and then multiplied by two.

Preparation of Input

The input is read in in free form. (The rules of free-form input are given in the S3359 document in detail.) The first card is a title card. The second card contains data specifying the symmetry of the function, the error tolerance which is compared with the least-squares error approximation, the maximum harmonic which is to be calculated, and a plot flag specifying what is to be plotted. The next set of cards contains values of θ and $f(\theta)$ where θ is in degrees.

Title Record

May contain any desired alphanumeric information

Control Record

IOEF	IOEF=0 if $f(\theta)$ is even, 1 if $f(\theta)$ is odd
ISYM	Specifies the symmetry of $f(\theta)$ as shown in Tables B-1 and B-2
E	Real number error tolerance allowed for Fourier series curve fit
N	Integer number specifying the maximum harmonic to be computed. Maximum of fifteen.
IPLOT	IPLOT=0, no plot

IPLOT=1, plot all harmonics

IPLOT=2, plot final harmonic only

IPLOT=3, plot specified harmonics

IH(15) Integer number specifying harmonic numbers to be used in plotting. Maximum of fifteen. Required only for IPLOT=3.

Input Data Cards

θ Real value of θ in degrees

$f(\theta)$ Real value of $f(\theta)$

The title card must be ended with a semicolon. All other data is separated by commas and ended with a semicolon. In choosing N and IH, the user must keep in mind what type of symmetry (IOEF and ISYM) he is working with. For example, if IOEF = 0, and ISYM = 1, only even harmonics are calculated since the odd harmonics are zero. Hence, N and the values of IH should be even.

If the Fourier coefficients are to be computed for more than one function, the data for each function is preceded by a title record.

Many functions of interest contain some type of symmetry. In these cases certain terms in the Fourier series will be zero and therefore are not calculated. The function f, in this case, is always either odd or even. The following rules of symmetry apply.

EVEN FUNCTION
Table B-1

Code	Function	Fourier Terms
ISYM=0	$f(\theta)=f(-\theta)$	no sine terms
ISYM=1 or 2	$f(\theta)=f(180+\theta)=f(180-\theta)$	no sine terms; no odd cosine terms
ISYM=3	$f(\theta)-f(180+\theta)=-f(180-\theta)$	no constant term no even cosine terms no sine terms

ODD FUNCTION
Table B-2

Code	Function	Fourier Terms
ISYM=0	$f(-\theta)=-f(\theta)$	no constant term no cosine terms
ISYM=1	$f(\theta)=f(180+\theta)=-f(180-\theta)$	no constant terms no cosine terms no odd sine terms
ISYM=2or3	$f(\theta)=f(180-\theta)=-f(180+\theta)$	no constant term no cosine terms no even sine terms

Note, for example, in the case where the function is odd and ISYM=1, that though only the even sin terms are being calculated, some of these might also be zero. These numbers most likely will not be zero in the output but only small

numbers. The user must decide whether or not they are zero.

Output

The entire input data is listed giving the FORTRAN name. The computed Fourier coefficients are written with a least-squares error for the curve fit up to that particular harmonic. A deck of cards containing the Fourier series coefficients is punched. The cards are punched in a form compatible with the input requirements of Program S3359.

If a plot is specified, a plot of the Fourier series curve fit is given on 12-inch grid paper. The actual curve is marked by X's, and the Fourier series curve fit is drawn with a solid line.

Sample Input

```
PRESSURE LOAD 1;

    1,1,.001,12,3,2,12;

    0.,2.;

    45.,2.;

    90.,2.;

    90,-2;

    135.,-2;

    180.,-2;
```

APPENDIX C

370 OPERATING INSTRUCTIONS

PROGRAM: STRESS ANALYSIS OF AN AXISYMMETRIC BODY WITH ASYMMETRIC LOADS

TAPES

Density	2 5 8 16	2 5 8 16	2 5 8 16	2 5 8 16	2 5 8 16
Data Set Name	SERVLIFE				
Input/ Output	I Ø	I Ø	I Ø	I Ø	I Ø
Reserve List Scratch	R L SC	R L SC	R L SC	R L SC	R L SC

CARD OUT YES NO

PLOTTER YES NO

ERROR PROCEDURE: Flush

ESTIMATED MAXIMUM RUNNING TIME: See user request

SPECIAL INSTRUCTIONS: None